THE SUBSTANTIAL CONSUMER BENEFITS OF BROADBAND CONNECTIVITY FOR U.S. HOUSEHOLDS

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EXECUTIVE SUMMARY

(1) Consumers receive more than $30 billion of net benefits from the use of fixed-line broadband at home, with broadband increasingly being perceived as a necessity

- Our estimates of the net consumer benefits from home broadband, based on sophisticated and reliable econometrics estimates from transactions data, are on the order of $32 billion per year, up significantly from the estimated roughly $20 billion in consumer benefits from home broadband use in 2005.
- This increased valuation corresponds to a changing perception over time by users, with broadband increasingly seen as a necessity for which users will find a way to pay.
    - For example, people appear unwilling to cut their broadband even when they lose their jobs, based on their need for connectivity as reflected in the significant jump upwards in use of job board and career information sites during the economic downturn.

(2) With even higher speed, broadband would provide consumers even greater benefits – at minimum an additional $6 billion per year

- Based on 2009 survey data, we estimate that the benefits of an increase in broadband speed from 100 times the typical historical speed of dial-up Internet service to 1,000 times dial-up are on the order of $6 billion per year for existing home broadband users.
- Households' valuations of higher-speed broadband depend on their experience with broadband: those who are connected to broadband at home value higher speeds over 40 percent more than those who have only home dial-up connections.

(3) Significant broadband *adoption* gaps exist between various groups of households

- For example, among all households in 2008 (including those off-line): 82 percent of Asian households were connected to broadband, while only 57 percent of black/African-American households had adopted it.
- 84 percent of "GenY" households (ages between 18 and 24) were connected to broadband at home, while only 43 percent of senior households (ages 65+) had adopted it.
- 83 percent of college graduate households were connected to broadband at home, while only 38 percent of households with less than high school diplomas had adopted it.

(4) Among those who are connected to broadband at home, there is no significant *valuation* gap based on race, although there are *valuation* gaps along other lines

- Among households that are connected to home broadband, blacks/African Americans, Asians and whites/Caucasians have similar valuations of broadband at home.

- However, there are significant differences in how much broadband is valued according to age, level of education, and income. For example, younger GenY and "GenX" heads of households (44 years of age and younger) value broadband much more than older householders (45 years of age and older).

(5) The total economic benefits of broadband are significantly larger than our estimates of the consumer benefits from home broadband

- Our benefit estimates are based exclusively on fixed-line Internet service connections to the home. The sizable benefits to households from mobile wireless broadband services are additional to our estimates.
- In addition, if many firms are using broadband to improve productivity, then as these firms compete with each other they will pass the gains along to consumers and these gains are also additional to our estimates. The economic gains to society as a whole from broadband adoption also include economic profits and producer surplus generated by the investments of broadband service providers and the providers of value-added services via broadband.
- These factors and others amount to billions and billions of dollars of additional economic gain to society each year from broadband adoption.

I. INTRODUCTION

The United States is now in the middle of a third major transformation in home computing. The first wave brought a computer to most homes: only eight percent of U.S. households had a computer in 1984, but more than half did by the year 2000. The second wave brought home Internet use. Only 18 percent of U.S. households had home Internet connectivity in 1997—the first year the U.S. Census Bureau began keeping such statistics. This was less than half of the U.S. households with computers (Newburger, 2001). But the home Internet transformation was underway at a revolutionary pace in the late 1990s. By 2000, 42 percent of all households had someone using the Internet at home. Moreover, the computer and the Internet had become intertwined into a unified technology, and more than 80 percent of all homes with a computer in 2000 were also homes with an Internet user.

This study focuses on a third transformation that has been taking place since about 2000: the transformation of home Internet use from what now already seem like clunky and out-dated dial-up services to broadband Internet use. In 2001, less than ten percent of U.S. households had home broadband connectivity to the Internet; by 2008, as we will document, 57 percent of households had home broadband connections.

Broadband is not only much faster than dial-up, but it is typically provided in a way that it is "always on." The combination of speed and availability makes home broadband connectivity an extraordinarily powerful and flexible tool that is already widely used for entertainment, work and job searches, news, health care, shopping, personal finances, social networking, and interactions with government. The economic and social transformations to households and business users from faster broadband speeds and more ubiquitous broadband connections are just beginning. Looking ahead, broadband is expected to have significant additional impacts on:

- *smart power grids* – installing two-way "smart meters" with wireless Internet will allow households to get detailed home energy usage from the web, with expected energy consumption savings, adjustment of appliances to reduce electricity consumption during peak times, and prevention or rapid repair of outages along the distribution grid;
- *workplace flexibility* – easy access to employer and public information should enable more work to be done at home, potentially benefitting both workers at established employers and at-home entrepreneurs;
- *health care information* – moving from paper files to electronic records should make it easier to communicate about health status and both past and potential future treatments, and to hold down treatment and administrative costs, which in turn should offer gains for patients and for health-care providers;
- *web 2.0 tools for civic elections* – broadband will facilitate even better information dissemination to citizens and election campaign staff during elections, and enhance connections to both on-line and off-line electoral activity.

But although we experience the changes wrought by widespread broadband adoption every day, and we can even catch intriguing glimpses of transformations yet to come, there are few broadly accepted estimates of the actual existing economic benefits of broadband to the U.S. economy.[1]

The main purpose of this study is to address this gap by measuring the portion of the benefits to the economy from broadband that accrue directly to its consumers, its "consumer surplus." This widely accepted microeconomic measure of consumer welfare is based on the idea that many of those who buy a product may value it at levels significantly higher than the price actually paid, while other buyers may value it only slightly more than or equal to the actual price. (Of course, those with an even lower value for the product would not make the purchase in the first place!) "Consumer surplus" is composed of the gap between what each consumer who purchased a product would have been willing to pay and what that consumer actually paid, summed up over all consumers who purchased the product. In this framework, the concept of consumer surplus captures the total value of broadband to consumers, over and above what they actually paid, and incorporates the value to them of all the new and existing activities that broadband makes possible as well as any cost savings to consumers which broadband facilitates.

There are two general methods to measure household consumer surplus. We use both for this study, employing two new data sets. The primary approach, which is more analytically complex, is based on annual data for Internet service prices and types purchased by a random sample of roughly 30,000 different heads of households located in the top 100 metropolitan regions across the United States. Households throughout the country face different prices and make different choices for Internet connections, and these differences can be used to infer econometrically the willingness of consumers to pay for such services. As a secondary methodology, we use a March 2009 survey on individuals' additional willingness-to-pay for Internet services beyond what was actually paid. We extrapolate from these samples to the U.S. population of relevant users of Internet services.

We begin in Section II with an overview of broadband supply and demand, first using publicly available aggregate data and then using a far more detailed household-level dataset. This overview sets the stage for the economic benefit calculations. Section III, the core of the paper, presents estimates of consumer surplus benefits from home broadband based on two distinct data sets and two different estimation strategies. Under the more sophisticated and reliable transactions-data based estimation strategy, the net benefits to U.S. households from home broadband relative to no home Internet are in the range of $32 billion per year. The lower consumer surplus estimate of roughly $23 billion per year relative to no home Internet from the survey-based method is likely due to the natural inclination of respondents to be too conservative when answering such surveys, fearing that they may be charged more if they reveal their full willingness-to-pay. Section IV extends the analysis by estimating the economic benefits associated with higher

[1] A main reason, no doubt, for the paucity of such estimates is the lack of appropriate publicly available data. For a summary of available studies, see Atkinson, Correa and Hedlund (2008), and Greenstein and McDevin (2009).

broadband speed, again using the March 2009 survey data on willingness-to-pay for such services. Perceived benefits of higher speed and the activities it enables are large, at minimum on the order of an additional $6 billion per year of consumer welfare for existing broadband users. Section V then examines the extent to which distinct demographic groups value the benefits from broadband differently and how their consumption patterns differ. Among those households that do adopt home broadband, broadband is valued highly across most demographic groups; indeed, African-American and Asian households, and rural households value broadband as much as whites/Caucasians and urban households, respectively. Section VI concludes by providing a broader context for these consumer surplus estimates. We emphasize that our estimates of the benefits from broadband are based exclusively on household users of fixed-line home Internet services, and thus constitute only a portion of the overall benefits of broadband to the U.S. economy.

II. EVOLUTION OF BROADBAND SUPPLY AND DEMAND

(1) Broadband supply and business user demand

From the late 1990s onward, vendors have been increasingly deploying fixed broadband lines.[2] Figure 1 and Table 1 present data on broadband lines connecting home and business locations to the Internet at speeds that exceed 200 kilobits per second (Kbps) in at least one direction. Table 1 breaks down these data into the four technologies through which this access has been provided: cable modem, which provides broadband over cable television infrastructure; DSL, which provides broadband over telephone lines; satellite, which is mainly used by those who are in remote areas; and fiber, whereby fiber-optic cable provides especially high-speed broadband connections.[3] In 2001, residential broadband lines accounted for 96 percent of total broadband lines, or 10.9 million lines out of a total of 11.3 million lines – while business lines accounted for the remaining 0.4 million lines. Between 2001 and 2007, residential broadband lines increased almost six-fold, to 64.1 million lines, while business lines increased nine-fold, from 0.5 million to 4.5 million lines.[4] However, given the lower starting point of business lines—reflecting the smaller number of business units to be connected relative to households—in 2007 residential broadband lines still accounted for 93.5 percent of total broadband lines. From 2007 to 2008, the total of broadband lines increased from

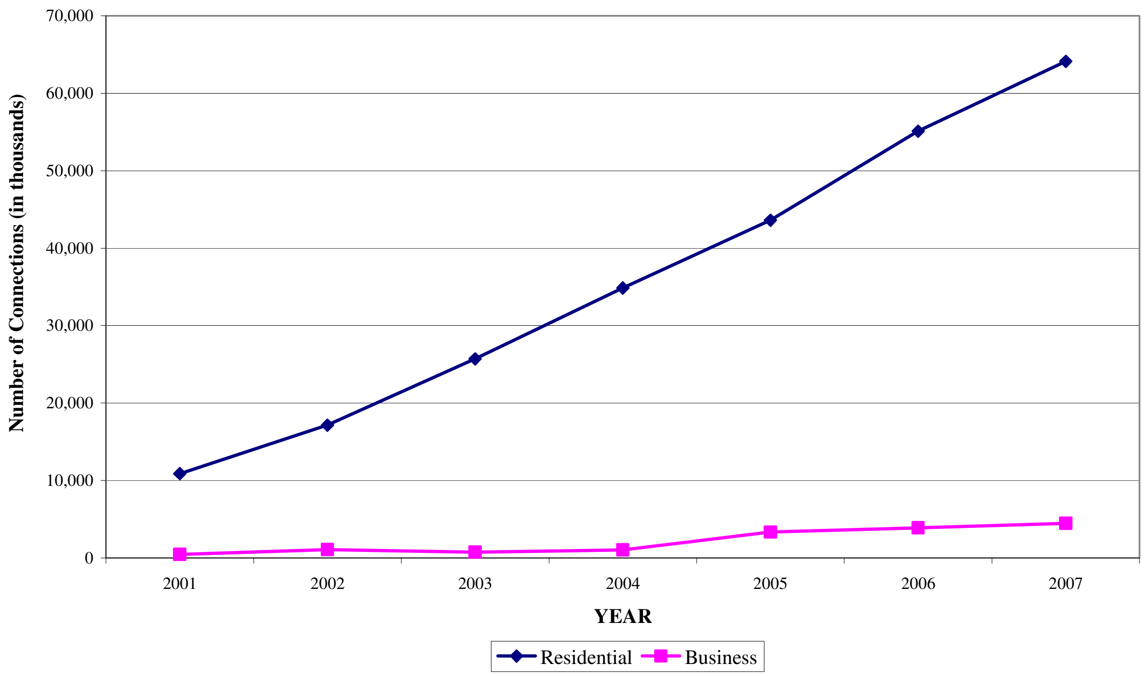
[2] The term "fixed-line" broadband is used here for a connection to a fixed end-user location, including not only actual wirelines (cable modem service over hybrid fiber-coaxial cable, DSL over copper, more advanced fiber networks) but also satellite. It does not include mobile wireless broadband services.

[3] In March 2008, the FCC upgraded its definition of "broadband" to begin at 768 Kbps, up from its previous definition of 200 Kbps and higher (i.e. faster speeds than traditional 56 Kbps dial-up or traditional 128 Kbps ISDN). This report will typically rely on the old broadband definition starting at 200 Kbps, given that data until very recently were classified along those lines.

[4] The FCC clarifies that high-speed line counts are not adjusted for the number of persons at a single end-user location who have access to, or who use, the Internet-access services that are delivered over the high-speed connection to that location – see "Notes for Tables 1-6 and Charts 1-10", FCC (2009). Given that many businesses get Internet over private lines, special access or high-capacity loops combined with their data lines, and often support hundreds or more Internet stations with such access, the undercounting of individual broadband users is likely to be particularly significant on the business side.

68.6 million to 77.4 million, allowing the U.S. to preserve its position as the most-wired country in the world in terms of broadband subscribers – though the U.S. ranks number 15 in percentage terms, based on the latest OECD broadband penetration rankings (at 25.8 broadband subscribers per 100 inhabitants).[5]

Figure 1: FIXED-LINE BROADBAND CONNECTIONS, RESIDENTIAL & BUSINESS



A complementary perspective on the relative importance of broadband to residential and business users can be drawn from the sales figures of Internet Service Providers (ISPs). The U.S. Census Bureau publishes figures for ISPs based on an annual survey of vendors.[6] Greenstein and McDevitt (2009) have made careful adjustments to the available figures to account for measurement problems over time, and report an astonishing growth in total revenues, from $5.6 billion in 1998 to $39.2 billion in 2006. Broadband revenues grew strongly as a share of the total over this period, from $0.14 million or less than three percent of the total in 1999 (when dial-up revenues accounted for more than 97 percent of the total) to $28 billion or 72 percent of total revenues in 2006. These publicly available Census data do not distinguish between household revenue and business revenue. However, based on household data for Internet service prices and type of services purchases, Greenstein and McDevitt conclude that between 70

[5] See OECD's official broadband statistics for 2008, released on May 20, 2009, at http://www.oecd.org/sti/ict/broadband. It should be noted that fixed broadband is purchased on a per-location, not per-person basis, so that the number of connections per inhabitant will vary across countries depending on the average size of a household or business establishment (and the size of households and business establishments varies significantly among OECD nations). See Ford (2009).

[6] Estimates from the latest Service Annual Survey are at www.census.gov/econ/www/servmenu.html, with revenues from cable modem vendors under NAICS 5175, DSL under NAICS 5171, and dial-up under NAICS 518111.

and 75 percent of broadband revenues is from households. Thus, according to these estimates, household broadband revenues were between $20 and $22 billion in 2006, while business revenues accounted for between $6 and $8 billion.

Table 1: FIXED-LINE BROADBAND CONNECTIONS
(over 200 Kbps in at least one direction)

Type of connection technology (in thousands)	2001	2002	2003	2004	2005	2006	2007
RESIDENTIAL							
Cable modem	7,050.7	11,342.5	16,416.4	21,270.2	25,714.5	31,118.1	35,332.6
DSL	3,616.0	5,529.2	8,909.0	13,119.3	17,370.5	22,768.5	26,477.7
Satellite	194.9	257.0	341.9	422.6	320.1	455.9	626.5
Fiber	4.1	14.7	19.8	35.0	213.5	763.4	1,684.1
TOTAL	10,865.7	17,143.4	25,687.1	34,847.1	43,618.6	55,105.9	64,120.9
BUSINESS							
Cable modem	8.9	26.6	29.9	87.2	843.7	863.6	1,164.7
DSL	331.8	942.5	600.4	698.0	2,145.0	2,644.3	2,974.0
Satellite	17.7	19.1	25.2	127.0	106.8	116.1	164.6
Fiber	87.8	93.8	96.6	124.7	234.8	272.3	166.6
TOTAL	446.2	1,082.0	752.1	1,036.9	3,330.3	3,896.3	4,469.9

Source: FCC (2009), with "Business" as the residual between Table 1 (total) and Table 3 (residential).
Note: "Residential" includes small business lines through end-2004. "Satellite" includes fixed and mobile wireless until end-2004. The term "fixed-line" is used for a connection to a fixed end-user customer location, including not only actual wirelines (cable modem service over hybrid fiber-coaxial cable, DSL over copper, more advanced fiber networks) but also satellite.

(2) Home broadband adoption and usage patterns

Home broadband adoption has increased dramatically, over six-fold, between 2001 and 2008. Table 2 shows that the increase has been fueled by both upgrading from dial-up and adoption by new users:

- *Increase in broadband adopters:* 66.6 million households used broadband in the home in 2008 (57 percent of households nationwide), more than six times the 10.4 million households in 2001 (ten percent of households nationwide). Yet 43 percent of U.S. households still had not adopted home broadband.[7]

- *Upgrading from dial-up:* Increased broadband use was significantly driven by upgrades from slower speed, not-always-on dial-up. The number and percent of dial-up households have fallen substantially, from 44.2 million households in 2001 (41 percent) to 10.5 million in 2008 (nine percent of households). The

[7] Horrigan (2009) reports that home broadband adoption increased to 63 percent of adult Americans as of April 2009, with dial-up Internet users at home decreasing further to 7 percent, and no home Internet users decreasing to 30 percent. This study uses the August 2008 figures reported in Table 2 for scaling up our calculated benefit numbers for 2008 so that the results from the larger 2008 household survey of the top 100 metropolitan regions, and the results from the March 2009 willingness-to-pay survey (scaled up by the number of broadband households in 2008) are comparable.

decrease in dial-up is paralleled by an increase in broadband from roughly 10 million to more than 66 million households during this time.

- *Uptake by new users:* Increased broadband was also driven by new home connections. Households with no home Internet fell from 53.6 million in 2001 to 39.7 million in 2008 (34 percent of households in 2008). Of those without home Internet connections, an additional roughly nine percent access at least some Internet services from other locations, leaving 25 percent of householders or 29.2 million households as non-users in 2008.[8]

Table 2: HOME BROADBAND ADOPTION
(millions)

Year	Broadband	Dial-Up	No Home Internet	Total Households
2001	10.4 (10%)	44.2 (41%)	53.6 (49%)	108.2
2002	15.3 (14%)	41.1 (38%)	52.9 (48%)	109.3
2003	22.7 (20%)	38.6 (35%)	49.9 (45%)	111.3
2004	28.7 (26%)	28.9 (26%)	54.3 (48%)	112.0
2005	36.5 (32%)	21.8 (19%)	55.0 (49%)	113.3
2006	46.3 (41%)	16.4 (14%)	51.7 (45%)	114.4
2007	58.9 (51%)	12.4 (11%)	44.7 (38%)	116.0
2008	66.6 (57%)	10.5 (9%)	39.7 (34%)	116.8

Source: "Internet Use Supplements" to the September 2001, October 2003 and October 2007 U.S. Census Current Population Surveys (CPS) as reported in NTIA 2002, 2004 and 2008, and Pew Internet and American Life Project's August 2008 survey for 2008 as reported in Horrigan (2008b), with assumed constant compound average growth rates for intervening years. Annual March CPS Surveys for national household figures (Table H1).

8 Horrigan (2008b) reports 25 percent non-Internet users based on the Pew Internet and American Life Project's August 2008 survey, a figure that has fallen to 21 percent according to the April 2009 survey (Horrigan 2009).

The publicly available data presented to this point are useful for aggregate trends, but less revealing of the nature of these trends. For this purpose, we turn to one of the two new datasets used in this study. For each year, this sample covers the prices paid and type of Internet service received by a nationally representative sample of roughly 30,000 different heads of households located in the top 100 Metropolitan Statistical Areas of the United States, from 2005 to 2008.[9] For each household, we observe the reported type of Internet connection used at home: either dial-up modem, broadband (broken down into cable modem, DSL, satellite, or fiber starting in 2007), or no home Internet connection. We also observe the reported average expenditure each month on home Internet connection.

Table 3 provides summary statistics for these data. The "maximum" and "minimum" values for each variable represent averages across households for entire Metropolitan Statistical areas; thus, they illustrate the significant variation in quantity and price of Internet service across the country. This variation in price and quantity of Internet services is critical to our study in the next section of the paper, because it can be used to infer econometrically how much people are willing to pay for different levels of Internet service—and thus to estimate the economic gains from providing faster and lower-cost broadband Internet service.

At a more aggregated level, it is noteworthy that the overall trends from these data—shown by the averages across all 100 Metropolitan Statistical Areas—are very similar to the trends over time from other publicly available data. Consider for example the statistics reported in Table 1 based on Federal Communications Commission data. The average increase in the national broadband share between 2005 and 2008 shown in Table 3 is 77 percent, which is almost precisely the same as the increase of 76 percent in the broadband share between 2005 and 2008 in Table 2. (The level of household broadband connections is higher in these data, presumably because the survey focuses on urban areas where broadband is more available.) Similarly, the mean cable modem and DSL prices in our market data are closely aligned with broadband prices reported in the National Telecommunications and Information Administration's latest broadband report (NTIA, 2008). The close correspondence between these survey data from 30,000 households and other national surveys gives us confidence that insights or conclusions based on these survey data are indeed representative for our purposes.

What types of online activities are underpinning the rise in broadband share from 39 percent in 2005 to 68 percent by 2008 (Table 3)? A range of representative online activities spanning entertainment, work, news and education, health care, shopping, and other personal and civic uses is presented in Table 4. Among broadband users, these data show sharp increases in the percentages of individuals engaged in specific online

[9] The sample of U.S. heads of households responded to a survey mailed to a random sample weighted by age, gender, household income, household size and composition, education level, region, and market size targets derived from the U.S. Census so that it is representative of the entire U.S. population (95 percent confidence interval +/- 0.4 percent). Households are randomly drawn from a panel of over 400,000 households and over 900,000 individuals. The top 100 Metropolitan Statistical Areas account for roughly 64 percent of the total U.S. population. The data are part of Forrester Research Inc.'s North American Benchmark Survey, fielded annually in the first quarter of each calendar year.

Table 3: SURVEY DATA - SUMMARY STATISTICS

Variable		2005	2006	2007	2008
Shares					
BROADBAND	Mean	**39.0%**	**51.0%**	**60.8%**	**68.5%**
	Max	54.6%	66.8%	80.9%	83.1%
	Min	23.8%	31.3%	32.6%	53.2%
Cable modem	Mean	22.3%	26.6%	29.6%	32.5%
	Max	36.3%	47.7%	55.8%	51.3%
	Min	7.4%	10.1%	13.6%	18.7%
DSL	Mean	16.3%	23.9%	29.2%	30.9%
	Max	35.6%	40.5%	60.8%	54.8%
	Min	3.6%	6.8%	8.8%	16.0%
Satellite	Mean	0.3%	0.5%	0.6%	0.9%
	Max	3.2%	2.3%	5.0%	3.7%
	Min	0.1%	0.1%	0.1%	0.2%
Fiber	Mean			1.5%	4.2%
	Max			6.1%	16.3%
	Min			0.1%	0.3%
DIAL-UP	Mean	**33.1%**	**26.3%**	**17.6%**	**11.4%**
	Max	52.9%	45.2%	43.6%	20.6%
	Min	21.5%	15.3%	7.4%	5.5%
NO INTERNET	Mean	28.0%	22.8%	21.6%	20.1%
AT HOME	Max	45.3%	40.6%	39.8%	35.9%
	Min	15.7%	10.7%	7.1%	7.9%
Prices (average monthly fees)					
BROADBAND	Mean	**$40.78**	**$39.16**	**$36.94**	**$35.37**
	Max	$49.95	$47.82	$46.31	$43.22
	Min	$34.29	$27.57	$25.85	$28.23
Cable modem	Mean	$42.24	$42.59	$42.30	$39.71
	Max	$51.34	$54.06	$54.42	$50.02
	Min	$32.19	$30.92	$31.71	$30.62
DSL	Mean	$38.32	$35.03	$30.65	$29.80
	Max	$54.31	$50.35	$44.10	$40.36
	Min	$25.80	$22.23	$15.94	$21.45
Satellite	Mean	$51.43	$50.92	$51.11	$44.42
	Max	$99.37	$139.25	$125.76	$130.50
	Min	$21.90	$21.34	$20.69	$20.00
Fiber	Mean			$39.59	$37.54
	Max			$103.64	$110.50
	Min			$20.69	$20.00
DIAL-UP	Mean	**$21.13**	**$19.85**	**$17.50**	**$17.18**
	Max	$26.72	$26.40	$30.96	$33.38
	Min	$13.50	$13.77	$11.21	$10.00
NO OF HOUSEHOLDS		34,031	33,589	24,691	26,878
Comparison broadband prices (average monthly fees)					
Cable modem		$42.13	$42.06	$40.59	$39.54
DSL		$37.60	$35.75	$36.59	$37.26

Source: Forrester data, NTIA 2008 (Chart 12) for comparison broadband prices.

Note: Mean, maximum and minimum values are across the top 100 MSAs (Metropolitan Statistical Areas) for each year.

activities over time. In fact, more than four-fold increases in activities that are undertaken at least weekly occur for visiting social networking sites (from 3.6 to 14.7 percent of broadband respondents) and watching videos online (from 5.2 to 21.3 percent). And roughly three-fold increases over this time occur for viewing or posting classifieds (from 2.5 to 8.9 percent over only three years) and publishing or maintaining a blog (from 1.3 to 3.5 percent).[10]

The data are also separated into broadband and dial-up users, which in turn reveal stark differences in the preferences of these two groups for some online activities—especially in areas where connection speed would be expected to make a significant difference in the online experience. In 2008, weekly activities that attracted significantly greater shares of broadband users compared to dial-up users include: playing online games with others (15.6 relative to 6.3 percent for "Generation Y" individuals in the 18-25 years bracket), watching videos online (21.3 relative to 5.2 percent), as well as listening to audio online (17.1 relative to 6.1 percent). The other activities (where the reported frequency share is less than weekly) that appear specifically suited for the faster speeds associated with broadband in 2008 include: working from home by connecting to one's at-work computer network (21.8 relative to 8.4 percent), bidding or selling in online auctions (47.1 relative to 28.0 percent), and doing financial activities online (75.5 relative to 53.7 percent).

In addition to entertainment, one important determinant of why people connect to broadband at home is for work. Many workers value home broadband because they feel it is essential for their job to stay connected at high speeds from home, either as a flexible part of work days, as systematic telecommuting, or for operating at-home businesses. Indeed, 17 percent of broadband users regularly used computers to work at home for their employers in 2007, relative to eight percent of dial-up users. As mentioned above, 22 percent of broadband users regularly used a computer at home in 2008 to connect to their employer's computer network, in contrast to only eight percent of dial-up users. Additionally, 13 percent of broadband users regularly used a computer to help run a business conducted from home, in contrast to only eight percent of dial-up users. Finally, both employed and unemployed workers value broadband as a means for accessing information about new job opportunities. Thirteen percent of broadband users used a job board or career information site in 2008 at least weekly, compared to only seven percent of dial-up users. Though the share of broadband users regularly using a home computer to connect to their employer's network decreased slightly from 21 to 17 percent between 2006 and 2007, the cause is likely that most work-from-home householders had already

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[10] The estimates here differ somewhat from the widely quoted Pew Internet and American Life Project surveys. One difference is that the Pew surveys are based on a significantly smaller sample size--on the order of 2,000 respondents per survey. But the primary difference is that the Pew surveys ask whether a respondent has *ever* done a certain activity. Given that distinction, the Pew survey reports similarly large increases: visiting a social networking site (from 8 to 29 percent, February 2005 to April 2008), watching a video online (from 33 to 52 percent, December 2006 to April 2008), and creating or working on your own online journal or blog (from 3 to 12 percent, July 2002 to February 2007). See www.pewinternet.org/ Reports/2008/Home-Broadband-2008.aspx, and the attached "Spring Tracking Survey 2008" which includes responses going back to 2000.

Table 4: HOME BROADBAND USAGE

Online Activity		2005	2006	2007	2008
Entertainment					
Play online games with others, for GenY	Broadband			**15.7%**	**15.6%**
individuals (at least weekly)	Dial-up			9.5%	6.3%
Watch any kind of video online	Broadband	**5.2%**	**7.1%**	**15.6%**	**21.3%**
(at least weekly)	Dial-up	1.7%	2.3%	4.4%	5.2%
Listen to any kind of audio online	Broadband	**7.8%**	**12.5%**	**12.7%**	**17.1%**
(at least weekly)	Dial-up	3.1%	5.3%	4.9%	6.1%
Work					
Regularly use home computer to work	Broadband	**20.4%**	**21.4%**	**17.1%**	
at home for your employer	Dial-up	11.7%	11.1%	8.1%	
Regularly use home computer to connect	Broadband	**23.4%**	**24.5%**	**21.3%**	**21.8%**
at home to employer's computer network	Dial-up	12.4%	13.0%	8.2%	8.4%
Regularly use home computer to help run	Broadband	**15.3%**	**14.6%**	**13.3%**	**13.0%**
a business conducted from home	Dial-up	11.1%	10.7%	8.3%	8.2%
Use job board or career info site,	Broadband	**7.9%**	**7.3%**	**5.8%**	**13.0%**
e.g. Monster.com (at least weekly)	Dial-up	1.7%	4.4%	5.1%	6.8%
News and education					
Use daily newspaper site (local, NYT, WSJ)	Broadband	**22.5%**	**23.9%**	**23.0%**	**19.2%**
(at least weekly)	Dial-up	17.4%	18.3%	15.4%	14.0%
Health care					
Researched a specific medical condition	Broadband	**7.8%**	**7.2%**	**8.2%**	**9.9%**
online (at least monthly)	Dial-up	5.9%	5.7%	6.9%	8.4%
Researched a specific drug/medication	Broadband	**5.7%**	**5.3%**	**6.2%**	**7.1%**
online (at least monthly)	Dial-up	4.3%	4.5%	5.5%	6.1%
Researched doctors' or hospitals'	Broadband	**1.1%**	**0.8%**	**1.2%**	**1.6%**
cost online (at least monthly)	Dial-up	0.6%	0.5%	0.8%	1.0%
Researched a doctor's or hospital's	Broadband	**1.1%**	**1.1%**	**1.4%**	**2.0%**
quality online (at least monthly)	Dial-up	0.6%	0.8%	1.1%	1.4%
Shopping					
Bid or sell in online auction,	Broadband	**34.3%**	**39.3%**	**46.5%**	**47.1%**
e.g. eBay (ever)	Dial-up	22.6%	24.0%	28.6%	28.0%
View or post classifieds,	Broadband		**2.5%**	**6.5%**	**8.9%**
e.g. Craigslist (at least weekly)	Dial-up		1.4%	3.9%	5.5%
Ordered product online and	Broadband	**80.8%**	**83.3%**	**78.7%**	**79.8%**
paid online (ever)	Dial-up	68.9%	69.4%	62.4%	61.8%
Other personal					
Visit social networking site, e.g. MySpace,	Broadband	**3.6%**	**7.8%**	**11.4%**	**14.7%**
Facebook, LinkedIn (at least weekly)	Dial-up	1.7%	4.4%	5.1%	6.8%
Do financial activities	Broadband	**72.0%**	**79.1%**	**78.1%**	**75.5%**
online (in past 3 months)	Dial-up	56.0%	59.7%	56.6%	53.7%
Civic					
Visiting government web site - federal,	Broadband	**63.1%**	**60.4%**	**67.6%**	
state or local (in past year)	Dial-up	57.1%	53.5%	57.7%	
Publish or maintain a blog	Broadband	**1.3%**	**1.9%**	**3.9%**	**3.5%**
(at least weekly)	Dial-up	0.9%	0.9%	1.8%	2.0%

Source: Forrester data. Figures are the number of broadband (and dial-up) users who participate in each activity as a fraction of the total number of broadband (and dial-up) users in each year.

acquired broadband connections by 2006, with those who adopted broadband for other uses increasing the broadband pool over subsequent years. Thus, it is likely that the expanding number of broadband users explains the decrease in the share of work-from-home householders.[11]

An important area where there has been an increase in usage, but where faster speeds associated with broadband do not yet seem critical is health care. There have been increases in the share of broadband users researching a specific medical condition online (from eight percent in 2005 to ten percent in 2008) and in researching a specific medication online (from six to seven percent). There has also been a two-fold increase (though from low levels) in the share of broadband users researching a doctor's or hospital's quality online (from 1.1 to 2.0 percent) and doctors' or hospitals' costs online (from 1.1 to 1.6 percent). This is an area where there will likely be an impetus for additional people to get broadband over time, as personal medical data are increasingly digitized as electronic health records.

Activities like using a daily newspaper site (roughly constant over the 2005-2008 period at 19-24 percent), or visiting a government web site (roughly constant over time at around 65 percent) do not appear to be the key drivers of increased broadband connectivity over recent years,[12] nor are they as overwhelmingly preferred by broadband relative to dial-up users (though even these activities are still significantly more frequently undertaken by broadband relative to dial-up users).

In considering these patterns of Internet use, it is important to remember that the frequency of use should not be equated to the importance of use. Certain activities that, on average, occur relatively seldom may be extremely highly valued by specific users. For example, even though only two percent of broadband users have reported researching a specific doctor's or hospital's cost or quality online, these information searches could be extremely valuable in a critical life-affecting decision – and will likely become more important as online cost and quality data improve over time. As another key example, one important spike in these data is the increase in the use of job board or career information sites in 2008 coinciding with the beginning of the U.S. recession. The share of broadband users accessing job boards or other career-related sites at least weekly jumped from six to 13 percent between 2007 and 2008. This suggests that people are unwilling to cut broadband usage even when they lose their job – to the contrary, broadband use appears to become much more valuable during such times.

[11] It is important to note that the declining share nevertheless represents a significant increase in overall home broadband workers, from 7.5 million users in 2005 (20.4 percent of 36.5 million users) to 10 million in 2007 (17.1 percent of 58.9 million users).

[12] This finding also emerges from the Pew surveys, with the share of respondents who have ever accessed news online roughly constant at 66-72 percent between 2002 and 2008, and who have visited a federal, state or local government website roughly constant at 50-65 percent between 2000 and 2008.

III. BENEFITS ASSOCIATED WITH HOME BROADBAND USE

How much are household consumers benefitting from home broadband services? Ideally, a measurement of such benefits should include the value that households place on all the activities that broadband makes possible, as well as the cost savings that use of broadband facilitates relative to alternative ways of achieving the same outcomes.

It is a fundamental insight of economic theory that the aggregate benefit to households from all their uses of a product or service like broadband can be assessed and measured by their total consumer surplus -- the sum total of the consuming households' levels of willingness to pay, less what they in total actually pay for broadband. Whenever a purchase occurs, the buyer values what is purchased by at least as much as the amount paid—otherwise, of course, the purchase would not have occurred. While household buyers within a given city or service area face the same prices for Internet service, households will differ considerably in the value that they place on that service. In other words, some households that buy broadband service will value it at just slightly above the market price; other households that buy broadband services will value it at considerably above the market price. This difference between the maximum price (sometimes called the "reservation price") that an individual consumer is willing to pay for the good and the actual price paid is called by economists the "consumer surplus" generated by the product for this individual.

Consumer surplus is the most direct measure that summarizes the economic benefits from the consumption of a particular good or service. These benefits are part of the household's real income, as well as the consumer welfare and real income of the whole economy. It is also important to recognize that there are other substantial components of the total economic benefit to the real income of the economy from a product or service like broadband. These include the benefits to the businesses that make use of broadband and, as discussed in Section VI below, the producers' surplus or profit impacts of broadband services on their suppliers and the supply chain.

There are two leading methodologies to measure consumer surplus, and this study employs both of them. Our primary approach is based on data for the Internet service choices consumers made in response to the prices they faced. This approach econometrically estimates demand functions that are identified by the variations in what prices households were charged at different places and times, and that describe how households differ in their consumption of Internet services in situations when prices are higher or lower. The households' levels of willingness-to-pay and consumer surplus are then inferred from the demand functions that are estimated from these data. As a secondary approach, we use data from a survey that typically asks consumers what they are willing to pay to compare their answers to what they actually paid and then calculate consumer surplus.

All empirical methods have imperfections and qualifications, and these two approaches to measuring consumer surplus are no exception. Answers to survey questions about willingness-to-pay may be distorted or unreliable; after all, what someone says in a survey may not reflect what they would actually do when facing a different set of choices about price and Internet service options. Econometric methods for estimating demand and inferring resulting levels of household willingness-to-pay require underlying assumptions and extrapolations, which can always be questioned. Here, we employ these two very different and independently developed data sets with correspondingly distinct but generally accepted rigorous analytic methodologies. Thus, it is highly reassuring and persuasive to recognize that both our different empirical approaches find large consumer surplus estimates from household broadband connections, although we find the estimate based on the transactions data more reliable and thus focus our attention on the results from that approach.

(1) Willingness-to-pay based on survey responses

In the survey approach to calculating consumer surplus, a representative sample of individuals is asked how much they value a specific product or service. Our results are based on data from a March 2009 survey administered to roughly 5,000 respondents[13], drawn from a random sample and weighted so that the data are representative of the U.S. online population—where "the online population" refers to those connecting to the Internet from some location (at home, work, school, Internet café, library, hotel, or elsewhere) at least monthly or more. We focus on the following question:

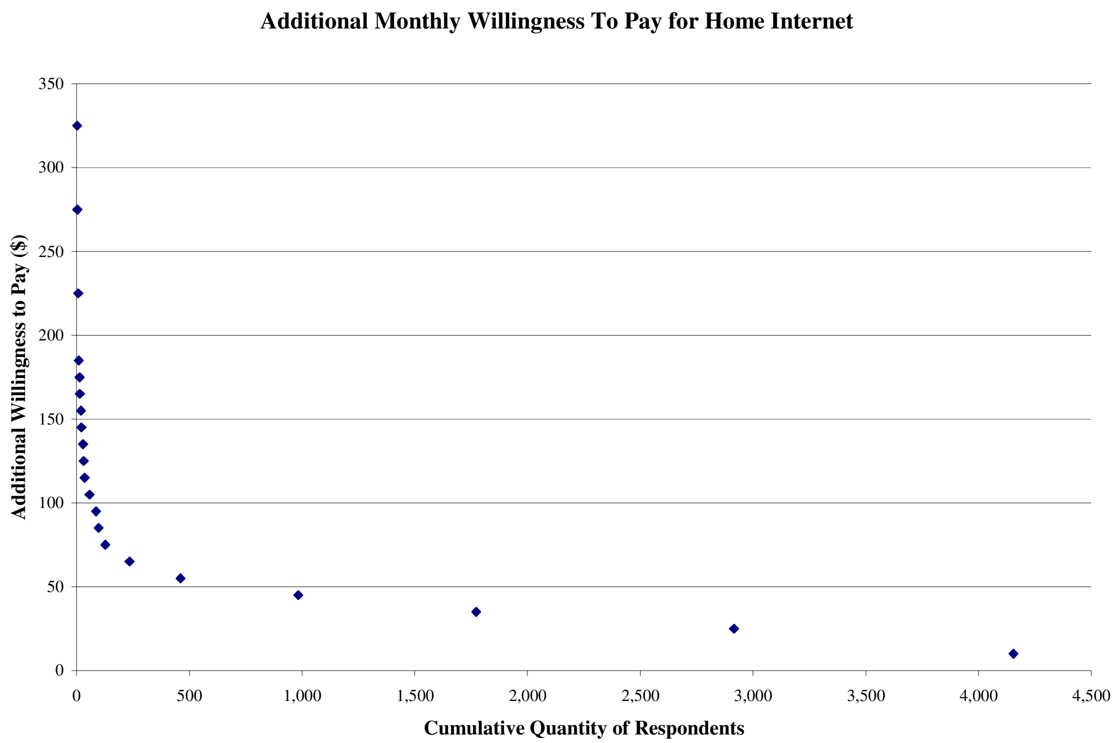
"What is the MOST additional you'd be willing to pay PER MONTH for your current Internet service, above and beyond any existing or advertised price that you are actually paying, with the understanding that the service would not be available unless you paid this much".

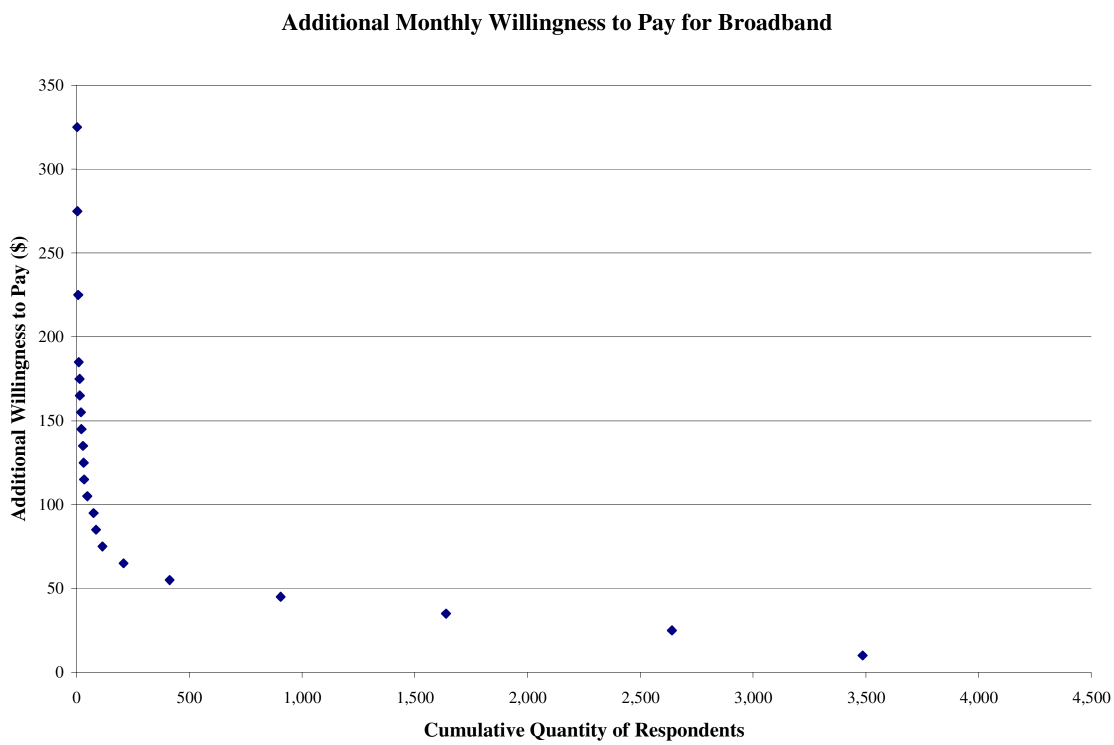
Figure 2 provides a graphical representation of the survey responses.

The top panel in Figure 2 shows the willingness-to-pay for the group of all Internet users in the sample with a home connection. The bottom panel shows the willingness-to-pay for only home broadband users. In both cases, the responses are additional willingness-to-pay beyond what was actually paid, relative to the situation of not having any home Internet connection. On both panels, the vertical axis shows the additional willingness-to-pay, above the current price, as measured in dollars per month. The horizontal axis is measured in a cumulative manner, for those respondents with a positive (non-zero) additional willingness-to-pay. The graph shows considerable heterogeneity in the demand for Internet service. For example, the first point of the top panel, indistinguishable from the vertical axis, means that two respondents have indicated the highest possible willingness-to-pay option in the question, of $325, given the very high cost to them of the alternative of no home Internet connection. The next point, still

[13] The data are part of Forrester Research Inc.'s North American 2009 Q1 Omnibus Online Survey. The sample of 5,007 U.S. individuals responding online is from a random sample weighted by age, gender, income, broadband adoption, region and technology attitude targets derived from the U.S. Census so that it is representative of the U.S. online population (with a 95 percent confidence interval +/- 1.4 percent). Individuals are randomly drawn from a panel of over 2.5 million individuals, with panelists recruited from a broad range of online and offline sources.

Figure 2: ADDITIONAL MONTHLY WILLINGNESS-TO-PAY
(March 2009)





indistinguishable from the vertical axis, means that two respondents indicated a willingness-to-pay of $275. Most respondents cluster toward the lower maximum additional willingness-to-pay price points of $10 or more and $25 or more. For the interval between the two lowest price points ($10 and $25), 1,239 respondents (the difference between 4,154 and 2,915) had a maximum willingness-to-pay for Internet service of $10 (the minimum non-zero option in the question, where the price range of "up to $20 more" was converted to its mid-point of $10).

These findings imply that home Internet connection and home broadband connection are creating at least moderate benefits for most users, but are also providing very large benefits to a small but significant group of users. In the two graphs, there is essentially a one-to-one match in the number of households willing to pay more than $55 above the prevailing price, which means that essentially all of the high-valuation households are broadband users.

To build up an estimate of total consumer surplus, we simply sum up the rectangles of the individual consumer surplus of all respondents with a positive willingness-to-pay.[14] By this calculation, the net monthly consumer surplus for the representative sample of home Internet households is $125,826. For the subsample of households with broadband service monthly consumer surplus is $111,669. We convert these monthly net consumer surplus numbers to an annual level by multiplying by 12. Finally, we scale up these annual numbers from our sample to a nationwide level by multiplying by a factor of 15,910 for all Internet households and by a factor of 17,038 for broadband households, as each of the 4,846 survey respondents with home Internet connection represents about 15,910 nationwide Internet households, and each of the 3,909 survey respondents with home broadband connection represents 17,038 nationwide broadband households (that is, the total number of 77.1 million U.S Internet households and 66.6 million broadband households in 2008 divided by 4,846 and 3,909 respectively). Annual consumer surplus for all U.S. households with Internet service is therefore $125,826 per month x 12 months x 15,910, which equals $24.0 billion of total consumer surplus for Internet use. Similarly, consumer surplus for broadband users is $111,669 per month x 12 months x 17,038, which equals $22.8 billion of annual total consumer surplus for broadband use.[15] As noted above, one must be cautious in relying on this survey-based method as a precise point estimate of the consumer benefits of broadband because of the natural inclination of survey respondents to be too conservative when answering

[14] This corresponds to estimating a broken or piecewise linear demand curve. Due to the meaning of the question posed by the survey, these estimates apply to the magnitude of benefits to households from their internet and broadband use based on the home connection already existing, and not the separate question of the additional economic gains from the deployment of broadband relative to the "what if" situation of no broadband deployment. On this distinct but complementary question, see Greenstein and McDevitt (2009).

[15] The 161 respondents out of 5,007 who reported not having a home Internet connection but nevertheless going online at least once a month indicated a monthly additional willingness-to-pay for Internet service of $2,361. This amounts to an additional benefit to the U.S. economy of $7.0 billion per year, or $2,361 per month x 12 months x 246,584 (where this latter scaling factor is based on the 39.7 million "no home Internet" households divided by 161). The data do not allow this benefit to be broken down by broadband versus dial-up.

such surveys, for fear that they may be charged more if they reveal their full willingness-to-pay.

(2) A model of demand based on transactions data

Our primary method for estimating consumer surplus is to use data from actual prices paid for Internet service and actual kinds of Internet service purchased (or not) by households at different times and in different geographic locations. The variations in price and quantity can be used, in the context of an economic and statistical model, to infer the willingness-to-pay for that service. In short, by examining the *actual prices* paid and the *actual choices* made by a substantial number of households for Internet service they desired, it is possible to estimate the value that households place on Internet services. The Appendix to this paper provides a detailed description of the economic model for carrying out this inference, and for the methods and calculations used. Here, we sketch the line of thought behind that model.

The approach of using data on prices paid and types of Internet services purchased to infer willingness-to-pay immediately encounters two main difficulties. The first problem is that in purchasing many ordinary goods, like pants, pizzas, or haircuts, the quantity can be measured in terms of the actual number of units of that good purchased. However, home broadband is not exactly purchased according to units, but instead based on a key product characteristic, speed. In other words, consumers of broadband are differentiated in their preference and willingness-to-pay for different levels of speed, namely broadband, dial-up, or no home Internet connection. Given how this product of "home Internet service" is supplied, with a monthly fee allowing access to any number of household members rather than a per-person usage fee that varies with the quantity consumed, Internet service demand is best modeled in terms of a discrete choice.

This issue is straightforward to handle, because there are long-standing statistical techniques (e.g. "logit" models) that can be applied when the decision is not how much of something to buy, but instead is a discrete choice to buy something or not. Extensions of this approach (e.g. "multinomial" and "nested" logit models) have been developed for which a range of products that are more-or-less substitutes for each other can be considered. The products can be grouped into "nests," so that differentiated versions of the product within one group or "nest" are closer substitutes than products from other groups. We consider three main groups: the broadband "nest," which includes cable modem, DSL, satellite and fiber as partial or close substitutes; the dial-up nest; and the nest for no Internet at home. This approach allows us to choose one nest as the basis to which all other choices are compared: thus, we analyze willingness-to-pay for all Internet connection choices—whether a version of broadband or dial-up—compared to the option of not having Internet service at all.

The second major challenge in using price and type data to estimate willingness-to-pay is that prices and quantities vary both because of variations in conditions of supply and variations in conditions of demand. Thus, the statistical problem is to distinguish only the variation that reveals demand and willingness-to-pay. A classic example may help with the intuition on this point. Imagine that you want to discover demand and willingness-to-pay for wheat, based on the price and quantity of wheat sold. The analytical problem is that a high price for wheat could be caused either by a surge of demand or a reduction in supply; conversely, a low price for wheat could be caused by a drop in demand or an increase in supply. Ideally, you would like to find a situation in which the price of wheat is moved at random, and then to observe how the quantity of wheat demanded changes in response. Nature provides one source of such randomness, with years of good weather and years of drought. By looking at years in which the price of wheat is driven up by drought, it becomes possible to infer the quantity demanded or willingness-to-pay for wheat at various prices. In the lingo of this approach, drought is the "instrumental variable" that allows sorting out willingness-to-pay from the mass of price and quantity data.

In our data set of 30,000 households over 100 Metropolitan Statistical Areas for the period from 2005 to 2008, we face this identical problem. A high price for Internet service in a given city might reflect an especially high demand for Internet services in that city, or it might reflect a limited supply of services in that city; conversely, a low price for Internet service in a given city might reflect an especially low demand for Internet services in that city, or it might reflect a high supply of services in that city. Ideally, we would like to find a situation in which the price of Internet service is moved at random, and then to observe how the type of Internet service demanded changes in response. But in this case, nature and weather do not provide a source of independent variation.

One approach that has been used in analogous circumstances (for example, Hausman, 1996) is to examine how variation in Internet prices in other cities affects the Internet service demanded in the remaining city. The underlying idea here is that a portion of the variation in Internet service prices over time in a given city is due to factors in the national economy that affect price, like changes in a common cost of technology affecting all providers in the national market, and that these national factors can be treated as a source of random variation. Another approach is to see how prices within the region in which a city is located—East, North-East, South and West—affect the Internet service demanded in that city. Again, the underlying idea is that a portion of price variation across cities at a point in time is not due to anything particular about each city, but instead is due to regional factors that can be treated as a source of random variation.

With an approach for modeling discrete choices among types of Internet service and with a source of random variation in price, the stage is set for our analysis. Our goal is to estimate the willingness-to-pay for a range of consumers of Internet services; thus, we seek to estimate how the type of Internet service demanded changes in response to variations in price. The difficulty, as noted earlier, is that variations in price and quantity demanded can occur for many reasons. We want to avoid looking at price fluctuations caused by interactions of supply and demand conditions in local markets because it will be impossible to draw inferences about the manner in which households react to prices based on these data. We instead want to estimate how the type of Internet service demanded changes with price fluctuations due to outside factors like national changes in technology and regional factors. We use a two-stage process: the first stage estimates the extent to which our "instrumental" variables, reflecting national and regional price changes over time, affect or are correlated with the prices paid by households. This first stage acts to eliminate any price changes caused by local fluctuations in supply and demand. With those local fluctuations out of the way, we can then move to the second stage: determining how consumers of Internet services react to price changes *based only on the price changes that arise from the independent factors*. This well-established process in the economics and statistics literature--sometimes called an "instrumental variable" approach and sometimes called "two-stage least squares"--allows us to produce an unbiased estimate of how the demand for a particular type of Internet service responds to (exogenous) changes in price.

These assumptions allow us to estimate the elasticity of demand, which indicates by what percentage the quantity demanded of a good will change in response to a certain percentage change in price. An elasticity of demand of -0.90, for example, means that a 10 percent rise in price will lead to a nine percent fall in quantity demanded (that is, 10 percent x -0.9). Using the data from roughly 30,000 households per year for 100 Metropolitan Statistical Areas from 2005 to 2008, we can estimate the elasticity of demand for dial-up and for each of the four varieties of broadband. Table 5 reports our estimated elasticities of demand. Our 2005 elasticity estimates are solidly in line with other available estimates: an own-price elasticity of demand for broadband of -1.53 and of dial-up of -0.90, and cross-price elasticity of broadband demand with respect to dial-up price of 0.44.[16]

What patterns emerge from these estimated elasticities—which, again, reveal how much the quantity demanded responds to changes in price? In 2005, demand for broadband service is still relatively price elastic, which means that relatively small changes in price will unleash relatively large changes in the quantity demanded: for example, a 10 percent fall in price for broadband via a cable modem would have led to a 51 percent increase in the quantity demanded. The quantity demanded of all the options within the broadband nest—cable modem, DSL, satellite and five—remain extremely sensitive to changes in price over time. This finding underscores a common observation from survey questions, namely that the feature that households most value from broadband service offerings, faster connection/greater speed, is not unique to any one connection mode within the broadband nest.[17] These extremely high elasticities indicate

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[16] As U.S.-based illustrations, Goolsbee (2006), based on late 1998 household data across 69 metropolitan areas, reports an average own-price elasticity for broadband of -2.75. Rappoport et al. (2003) based on 2000 household data and a nested logit model without instrumental variable estimation reports an own-price elasticity of -1.46 for broadband (DSL). Rappoport et al.'s (2003) estimates of the own-price elasticity for dial-up range between -0.17 to -0.37, while their estimate of the cross-price elasticity of dial-up for those with broadband is 0.02.

[17] Based on those who have high-speed Internet at home (those who are in the broadband nest), the feature that respondents to the spring 2008 Pew Internet and American Life Project survey liked most about their high-speed connection at home was faster access/greater speed, with 75 percent of respondents selecting this option (with the next most popular response, with 6 percent of respondents, being the "always-on" connection). This response has been fairly consistent over time, with a similar question in the October 2002 survey having 77 percent of respondents selecting connection speed.

that if one form of broadband were to become noticeably cheaper compared to others, broadband users would flock to that choice.

Table 5: NESTED LOGIT ELASTICITIES AND CONSUMER SURPLUS ESTIMATES WITH VARYING URBAN-RURAL PREFERENCES

Variable	2005	2006	2007	2008
ELASTICITIES				
Dial-up own price	-0.90	-0.95	-0.92	-0.96
Dial-up broadband cross price	0.44	0.33	0.19	0.12
Broadband own price	-1.53	-1.17	-0.88	-0.69
Cable modem own price	-5.12	-5.48	-5.59	-5.21
DSL own price	-5.71	-4.78	-3.98	-4.04
Satellite own price	-11.27	-11.37	-10.73	-9.94
Fiber own price			-8.70	-8.11
CONSUMER SURPLUS ($ billions)				
Home Internet (relative to no home Internet)	28.01	32.01	33.33	35.63
Broadband (relative to no home Internet)	**20.14**	**25.37**	**27.94**	**31.86**
Broadband (relative to Dial-Up)	12.01	15.52	18.73	23.40

Source: Forrester data. See Section 1 of the Appendix for underlying calculations.

Our approach also allows us to estimate various measures of "cross-price elasticity of demand," which is the extent to which demand for some form of internet service changes as the price of another form changes. For example, Table 5 shows that in 2005, the cross-price elasticity of demand for broadband with respect to the price of dial-up was a relatively low 0.44, which means that a rise of 10 percent in the price of dial-up would have caused only a 4.4 percent rise in the quantity of broadband demanded. Again, this estimate is similar to those from previous studies.[18] It illustrates that in 2005 dial-up and broadband internet services were only moderately close substitutes for consumer demand.

What is perhaps most striking in the elasticity estimates in Table 5, however, is the progressive decline over time in the own-price elasticity of broadband, from -1.53 in 2005 to -0.69 in 2008.[19] In other words, in 2005 a 10 percent rise in the overall price of

[18] As mentioned earlier, Rappoport et al.'s (2003) estimates of the own-price elasticity for dial-up range between -0.17 to -0.37, while their estimate of the cross-price elasticity of dial-up for those with broadband is 0.02. Cardona et al. (2009), based on Austrian data, report a cross-price elasticity of dial-up for broadband of 0.23.

[19] Prior to estimating this nested logit model, we also estimated a standard flat logit model where households are faced exclusively with the choice between broadband, dial-up and no Internet, without the added Internet connection choices within the broadband nest. The own-price elasticities of demand for

broadband would have led to a 15.3 percent decline in the quantity demanded, but by 2008, a 10 percent rise in the price of broadband would lead to only a 6.9 percent decrease in the quantity of broadband demanded. This result indicates that broadband is progressively being perceived by those who are using it as a household necessity. Moreover, the perceived value of broadband to households is rising, and therefore they are increasingly less willing to alter their broadband purchases in response to a change in price. Indeed, a recent survey of what Americans consider as a "necessity" or a "luxury" finds that 31 percent of Americans consider broadband Internet a "necessity". This puts broadband Internet ahead of "dishwasher" or "cable or satellite TV" in the necessity rankings.[20]

Estimates of the elasticity of demand can be used to infer an estimate of consumer surplus. The own-price elasticity of demand indicates what quantity of broadband or dial-up would be demanded if the corresponding price were higher; in turn, this calculation reveals what share of users would be willing to pay a higher price. For example, with the price elasticity of demand for broadband in 2008 of -0.69, a 10 percent rise above the 2008 price would have led to a 6.9 percent fall in quantity demanded; showing that the remaining 93.1 percent of consuming households had a willingness to pay for broadband at least 10 percent higher than the 2008 price. A higher price elasticity means that quantity demand will be driven down to a greater extent by equal size price increases, indicating that relatively fewer people place higher values on the good. In contrast, a lower price elasticity means that demand is less sensitive to price increases, indicating that more people place relatively higher values on the good.

Thus, the declining value of the price elasticity of demand for broadband over time means rising estimates of consumer surplus that measure the increase in value of broadband to households over time. Consumer surplus from broadband relative to no home Internet connection, at $20.1 billion in 2005, was about 70 percent of total consumer surplus for home Internet, including broadband and dial-up, at $28.0 billion. Between 2005 and 2008, net consumer surplus for broadband increased by about 60 percent, to $31.9 billion.[21] And by 2008, the net benefits to households from broadband accounted for roughly 90 percent of the net benefits to households from all home Internet services – with the relative benefits from dial-up having shrunk roughly three-fold, from about 30 percent to about 10 percent of a larger pie, as accustomed consumers of higher-speed Internet were deriving more and more benefits with an increasingly wide range of newer applications. Estimates for the distinct but also relevant question of consumer surplus from broadband relative to home dial-up connection are also provided in Table 5.

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broadband were somewhat lower in that model, with an elasticity of -1.09 for 2005. However, that model generated the same striking decrease in elasticities over time, to -0.49 in 2008.

[20] See Morin and Taylor (2009). The website for the report is http://pewsocialtrends.org/assets/pdf/luxury-or-necessity-2009.pdf. In this survey, a lot of older technologies have dropped in the necessity rankings (such as clothes dryer, TV set, microwave, and air conditioning, each down more than 10 percent), while high-speed Internet is up, even though only by 2 percent since 2006.

[21] For details on how the nested logit was used to calculate economy-wide consumer surplus, how our preferred model allows household preferences to vary across markets depending on their urban-rural mix, and how we scale up our estimates to the U.S. household population based on findings from the largest 100 MSAs and rural intensity data from the rest of the country, see Section 1 of the Appendix to this paper.

However, the key estimates emphasized here are the broadband estimates relative to no home Internet connection. They are the most directly comparable to the survey-based willingness-to-pay calculation, and both of these estimates are more pertinent to the benefits that could presumably be gained by enabling the significant 34 percent of households that had no home Internet connection in 2008 to be connected to broadband.

The estimates of consumer surplus gains for households from home broadband use relative to no home Internet connection are significantly higher from the more sophisticated and reliable method which derives elasticities of demand from price and quantity information rather than from the survey-based method — roughly $32 billion per year in the former case and $23 billion per year in the latter case. As noted above, we find the former approach more reliable than the latter because it is based on data on households' actual choices in the market rather than on what respondents assert are their levels of willingness-to-pay, without strong incentives to introspect and articulate the truth.

IV. BENEFITS ASSOCIATED WITH HIGHER BROADBAND SPEED

How much do households value higher broadband speeds than what they are currently used to—say, on the order of 50 megabits per second (Mbps)? Our results here come from the same kind of calculation that we did to derive our survey-based estimate of consumer surplus explained above. However, as we will discuss, asking questions about a technological improvement that some households already have, while others do not, complicates the problem of drawing inferences from the survey results.

Our results are founded on data from the same March 2009 willingness-to-pay survey we employed above. After the basic question put to respondents on their willingness-to-pay for current Internet service, the survey offered the following additional add-on question:

"What is the MOST additional you'd be willing to pay PER MONTH for the following high-speed Internet services, above and beyond any existing or advertised price that you are actually paying, with the understanding that the service would not be available unless you paid this much:

1. *Download speed of 100x Dial-up (5 Mbps or megabits per second), e.g. allowing a 2-hour 5GB high-definition movie to be downloaded in about 15 minutes*
2. *Download speed of 1000x Dial-up (50 Mbps), e.g. allowing a 2-hour 5GB high-definition movie to be downloaded in about 1.5 minutes".*

Again, we found considerable heterogeneity in the willingness of households to pay—in this case, for faster speeds. We again summed up the rectangles of consumer surplus for all home broadband respondents with a positive willingness-to-pay to capture the pattern of a relatively small number of households who place relatively high values on greater speeds, as well as the bulk of households who place a more moderate value on greater speeds. This methodology found that the net consumer surplus across the sample responding to the question of willingness-to-pay for broadband connection speed of 5 Mbps is $92,262, while the consumer surplus across the sample responding to the question of willingness-to-pay for broadband connection speed of 50 Mbps is $119,693. We scale up these monthly willingness-to-pay numbers by 12 to get annual figures. Next, we scale up these annual numbers from our sample to a nationwide level by multiplying again by a factor of 17,471 (the total number of 66.6 million broadband households in 2008 divided by the 3,812 survey respondents with home broadband connection) to get nation-wide figures. Accordingly, the additional consumer surplus if all current home broadband households were able to have a broadband connection speed of 5 Mbps is $92,262 per month x 12 months x 17,471, for a total consumer surplus of $19.3 billion. Similarly, the calculation for additional consumer surplus if all these same households had a broadband connection speed of 50 Mbps is $119,693 per month x 12 months x 17,471, for a total consumer surplus of $25.1 billion. The difference between the two figures, $5.8 billion, represents the currently perceived benefits of an increase in broadband speed from 100 to 1000 times dial-up, or from 5 to 50 Mbps, for current home broadband households.

Our estimate that the perceived benefits to existing U.S. broadband households of higher broadband speed are on the order of $6 billion per year in early 2009 is likely to be a significant underestimate for several reasons. The primary reason is that some of those households have already experienced the higher speeds, while many have not. Related survey research typically finds that users express a larger willingness-to-pay to avoid having something taken away from products that they already have experienced positively, than for products that they have yet to experience. This is likely to be the case for broadband Internet, which is a classic "experiential good"—that is, where the experience is significantly different than dial-up. Thus, as more households experience a very high-speed broadband connection, their answers to these kinds of survey questions would in all likelihood be higher.

To get a sense of the magnitudes involved with this issue, we disaggregated respondents to the 50 Mbps question, depending on whether they are currently broadband Internet users, or dial-up users. The difference in willingness-to-pay for higher speeds is striking: the monthly net additional willingness-to-pay per household for a speed of 1,000 times dial-up speed for existing broadband users is $31.40, while it is just $21.93, or roughly 43 percent less, for those who currently have a dial-up Internet connection. This difference should not be treated as an accurate measure of how all households will come to value higher speeds of broadband as they experience higher speeds; after all, those who currently have broadband are not a randomly chosen group, and there may well be other reasons why they place a higher value on broadband adoption. Nonetheless, the difference does suggest that those who already have higher speeds tend to place a greater value on still-higher speeds.

Finally, if much higher broadband speeds were common, then a variety of additional online activities taking advantage of those speeds would become economically viable. As these additional innovations arise, the valuations placed on extremely high-speed broadband will likely become much higher.

V. THE EFFECT OF DEMOGRAPHICS ON BROADBAND ADOPTION AND VALUATION

(1) Broadband adoption demographics

How important have household characteristics been in affecting the choice of broadband? This section examines the extent to which household income, age, race/ethnicity, education, employment status, and location (urban versus rural location based on population density) characteristics have influenced the rapid adoption of broadband connections across households, as reflected in our data over the years 2005-2008.

Table 6 presents simple tabulations depicting broadband adoption rates for our key demographic subgroups. For each particular subgroup in a given year, the leading reported broadband adoption rate is the share of households from that subgroup having adopted broadband relative to all households within that subgroup- – including those with home broadband, dial-up and no home Internet. In parentheses, directly below each of these figures, is the share of the subgroup having adopted broadband relative to all Internet households from that subgroup; that is, relative to households with either home broadband or dial-up.[22] This measure highlights the demographic subgroups that may be more likely to switch, relatively more rapidly, to broadband in the coming years – as dial-up becomes less and less prevalent, and remaining dial-up users may be more likely than those with no home Internet to switch to broadband. Indeed, a number of patterns are worthy of highlight:

- *Household income:*[23] The likelihood of adopting home broadband increases with income. In 2008, 88 percent of high-income households (with annual household income exceeding $100,000) were connected to broadband, while only 41 percent of low-income households (with annual income less than $25,000) had adopted it. The differences in all the income-related broadband adoption rates are statistically significant at standard levels of significance (at the 95 percent level). The starkly lower broadband adoption rate all low-income households (at 41 percent) relative to the higher broadband adoption rate for low-income Internet households (in parentheses directly below, at 77 percent) highlights the much larger number of low-income households that still have no home Internet connection – and could suggest that the low-income demographic subgroup will be slower adopters of

[22] For a more rigorous statistical methodology that allows the percentages to be adjusted (or controlled) to take into account the impact of every other demographic variable, including varying household size, see section 2 of the Appendix. The basic tabulations here present a meaningful qualitative picture of the effect of the demographics on broadband choice.

[23] The lower income line of $25,000, and other income lines, are based on median household income of roughly $50,000, with "middle income" typically thought of as ranging from half this figure to twice the number, or roughly $25,000 to $100,000. Based on 2008 U.S. Census Bureau data, the income line between the lowest and second household income quintile is $20,300, and the income line between the fourth and highest quintile is $100,000. The U.S. Department of Health and Human Services 2009 Poverty Guidelines provide a simplified poverty threshold of $14,500 for a 2-person household, and $22,000 for a 4-person household.

broadband over the next years, given that they still largely have no home Internet connection at all.

- *Age*: The likelihood of adopting home broadband decreases with age. Among all households in 2008, 84 percent of "GenY" and 81 percent of "GenX" households (where the age of the head of household is between 18-24 and 25-44, respectively) were connected to broadband at home, while only 43 percent of seniors (ages 65+) had adopted it. The differences in all the age-related adoption rates, except between GenY and GenX households, are statistically significant at standard levels of significance. The starkly lower broadband adoption rate for all senior households (at 43 percent) relative to the higher broadband adoption rate for senior Internet households (in parentheses directly below, at 77 percent) highlights the much larger number of senior households that still have no home Internet connection at all.

- *Race/ethnicity:* The likelihood of adopting home broadband varies by race/ethnicity. In particular, among all households in 2008, 82 percent of Asian households were connected to broadband, while only 57 percent of blacks/African-American households had adopted it. The lower broadband adoption rate for all black households (at 57 percent) relative to the higher broadband adoption rate for black Internet households (at 84 percent) highlights the much larger number of black households that still have no home Internet connection. It also is interesting to note that black households are not statistically different from white or Latino households in their adoption of broadband relative to Internet, or relative to dial-up (that is, 84 percent and 86 percent are statistically indistinguishable).

- *Education:* The likelihood of adopting home broadband increases with education. Among all households in 2008, 83 percent of households headed by college graduates were connected to broadband at home, while only 38 percent of households headed by those with less than high school diplomas had adopted it.

- *Employment:* The likelihood of adopting home broadband increases with employment. Among all households in 2008, 79 percent of employed heads of household were connected to broadband at home, while only 49 percent of retired households had adopted it.

- *Location (based on population density):* The likelihood of adopting home broadband varies according to population density, where households are defined as "urban" if they reside in zip codes with a population density of 1,000 people or more per square mile. However, the difference is small in magnitude. Among all households in 2008, 70 percent of urban households were connected to broadband at home, while 67 percent of rural households had adopted it.

Table 6: BROADBAND ADOPTION BY DEMOGRAPHIC CHARACTERISTICS

Demographic characteristic	2005	2006	2007	2008
HOUSEHOLD INCOME				
Low income (to $25K)	18%**	26%**	32%**	41%**
	(44%)	(53%)**	(64%)**	(77%)**
Lower middle income ($25-50K)	31%**	44%**	53%**	61%**
	(46%)	(59%)**	(71%)**	(80%)**
Upper middle income ($50-100K)	47%**	60%**	71%**	78%**
	(55%)**	(67%)**	(80%)**	(87%)**
High income (+$100K)	60%**	75%**	82%**	88%**
	(65%)**	(79%)**	(86%)**	(93%)**
AGE OF HOUSEHOLDER				
GenY (18-24)	52%**	67%**	72%	84%
	(65%)**	(80%)**	(84%)	(94%)**
GenX (25-44)	46%**	62%**	71%	81%
	(56%)	(71%)**	(82%)	(90%)**
Boomer (45-64)	40%**	49%**	61%**	69%**
	(54%)	(63%)**	(76%)**	(84%)**
Senior (65+)	18%**	27%**	39%**	43%**
	(42%)**	(51%)**	(67%)**	(77%)**
RACE/ETHNICITY				
Asian	56%**	72%**	74%**	82%**
	(65%)**	(79%)**	(83%)	(90%)**
White/Caucasian	40%	52%	63%	70%
	(54%)	(66%)**	(78%)	(86%)
Latino/Hispanic	38%	54%	61%	74%
	(54%)	(70%)**	(79%)	(86%)
Black/African American	27%**	37%**	46%**	57%**
	(47%)**	(59%)**	(72%)**	(84%)
EDUCATION				
Less than high school diploma	18%**	27%**	31%**	38%**
	(46%)	(57%)	(62%)**	(77%)
High school diploma	27%**	38%**	49%**	56%**
	(46%)	(58%)	(72%)**	(81%)
Some college	42%**	55%**	64%**	73%**
	(54%)**	(67%)**	(78%)**	(86%)**
Bachelors degree or more	52%**	65%**	74%**	83%**
	(59%)**	(71%)**	(82%)**	(90%)**
EMPLOYMENT				
Full-time employed	46%**	59%**	70%**	79%**
	(56%)**	(69%)**	(80%)**	(88%)**
Part-time employed	40%**	53%**	61%**	73%**
	(53%)	(66%)	(76%)	(86%)**
Unemployed	35%**	47%**	53%**	64%**
	(53%)	(66%)	(75%)	(83%)**
Retired	20%**	30%**	42%**	49%**
	(43%)**	(52%)**	(69%)**	(80%)**
LOCATION (POPULATION DENSITY)				
Urban	41%**	54%**	63%**	70%**
	(57%)**	(69%)**	(80%)**	(88%)**
Rural	36%**	47%**	58%**	67%**
	(48%)**	(61%)**	(72%)**	(83%)**

Note: Forrester data based on households from the top 100 MSAs for each year. For each particular demographic category subgroup and year, reported percentages are the share of home broadband adopters relative to all households (and relative to Internet households in parentheses). ** indicates that differences with all other percentages in the same demographic category are statistically significant at the 95% level.

(2) Willingness-to-pay demographics

A separate and highly relevant question is the direct effect of demographic indicators on additional willingness-to-pay—and thus on consumer surplus—for broadband. Of those online households that are connected to home broadband, do lower middle-income households or African-American households, for instance, put as much value on broadband as upper middle-income, white households? In fact, the answer to this question turns out to be affirmative. To formulate such conclusions, we examined the extent to which household income, age, race and ethnicity, education, and employment affect willingness-to-pay for broadband, based on the March 2009 willingness-to-pay survey.

The key difference between the analyses of patterns of adoption and patterns of valuation is that distinctly different groups are being compared. In the former case, we examine the share of all households (including those that are not connected to Internet at home), from a particular subgroup, that are connected to home broadband. In the latter case, we examine only the valuation of broadband by those households that are connected to broadband at home.[24] The patterns are broadly similar across most demographic categories, with both adoption and valuation increasing with income, decreasing with age, and increasing with education and employment. However, one striking difference emerges where households are disaggregated by race/ethnicity: black/African-American households have a below-average adoption rate of 57 percent, while the valuation of connected black/African-American households, at $32.10, is above average (though statistically indistinguishable from the valuation of white/Caucasian households at $28.69 and of Asian households at $27.47). This is explained by the large number of black/African-American households that still have no home Internet connection, which is why the overall adoption rate is so low. On the other hand, those online black/African-American households that have experienced a connection to broadband at home value the experience highly.[25]

Figure 3 presents a graphical representation, and Table 7 presents the underlying data, of simple tabulations of willingness-to-pay for broadband broken down by demographic characteristics of existing home broadband users.[26] The key patterns are:

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[24] There are insufficient responses to the March 2009 willingness-to-pay question by those that are not connected to Internet at home in order to allow a statistically significant analysis by demographic categories.

[25] No doubt income is an important enabler of experiencing broadband at home: of those African-American households that have home broadband, 16 percent are high income and 22 percent are low income, while of those African-American households that have no home Internet connection, only 3 percent are high income while 57 percent are low income.

[26] For a more rigorous statistical methodology that allows willingness to pay to be adjusted (or controlled) to take into account the impact of every other variable, see section 3 of the Appendix. The basic tabulations here present a meaningful qualitative picture of the effect of the demographics based on rectangle measures of willingness-to-pay.

Figure 3: WTP BY DEMOGRAPHICS
(point estimates and 95% confidence intervals)

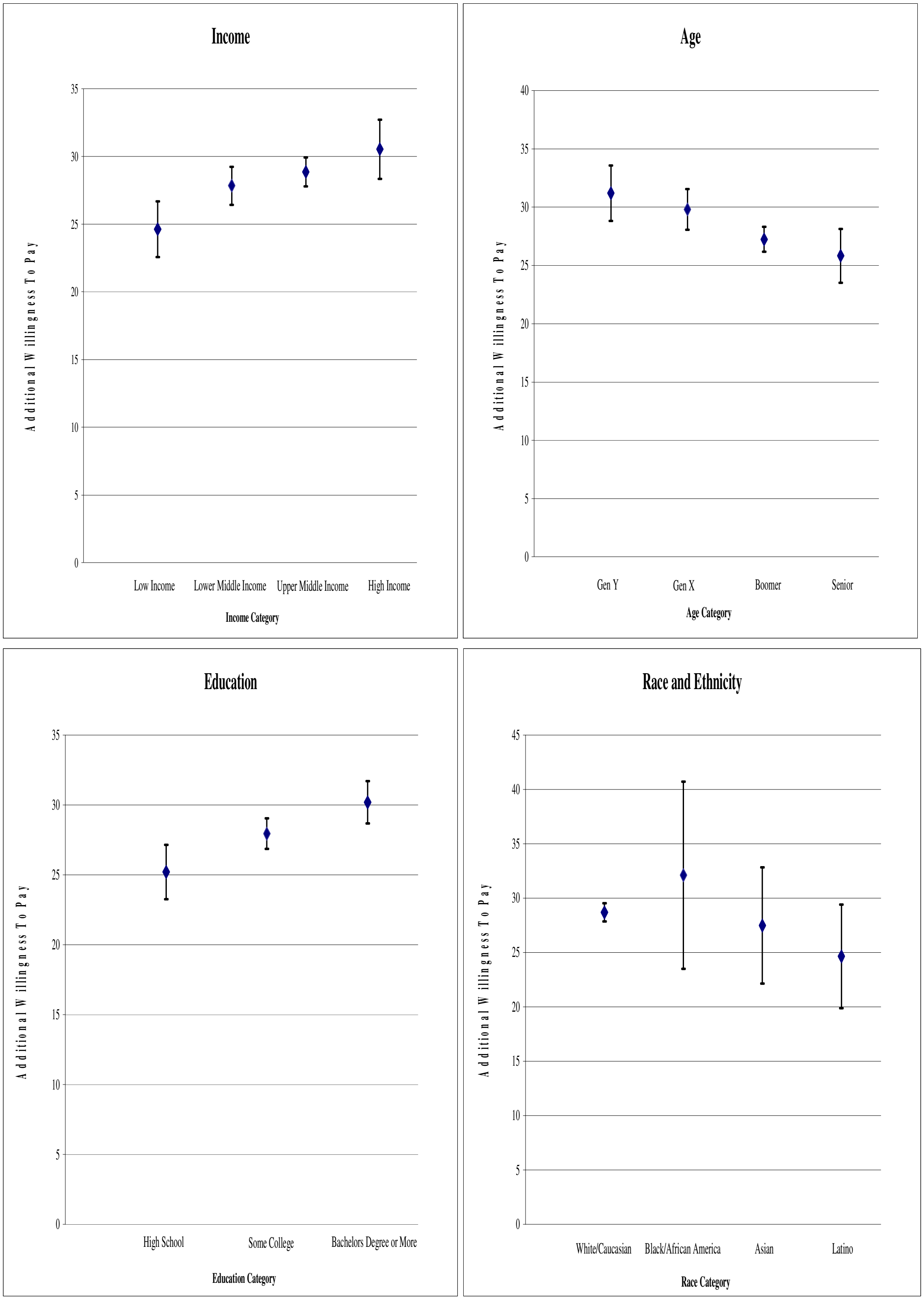

Table 7: ADDITIONAL WILLINGNESS-TO-PAY FOR BROADBAND BY DEMOGRAPHIC CHARACTERISTICS

Demographic characteristic	Willingness-to-pay
HOUSEHOLD INCOME	
Low income (to $25K)	$24.62
Lower middle income ($25-50K)	$27.84
Upper middle income ($50-100K)	$28.85
High income (+$100K)	$30.52
AGE OF HOUSEHOLDER	
GenY (18-24)	$31.19
GenX (25-44)	$29.80
Boomer (45-64)	$27.23
Senior (65+)	$25.82
RACE/ETHNICITY	
Black/African American	$32.10
White/Caucasian	$28.69
Asian	$27.47
Latino/Hispanic	$24.64
EDUCATION	
High school diploma or less	$25.20
Some college	$27.95
Bachelors degree or more	$30.19
EMPLOYMENT	
Employed	$29.56
Student	$30.01
Retired	$26.44
Unemployed	$26.69
LOCATION (POPULATION DENSITY)	
Urban	$28.49
Rural	$28.78

Note: Forrester data based on the March 2009 survey. Additional willingness-to-pay figures are average rectangle measures of consumer surplus across all respondents within each demographic category subgroup.

- *Household income*: Household income is a significant determinant of willingness-to-pay for broadband, with willingness-to-pay increasing with income levels. The average low-income householder's additional willingness-to-pay is $24.62, which is significantly lower than the average upper middle-income's valuation of $28.85, as well as the average high-income's valuation of $30.52. There is no statistically significant difference in willingness-to-pay among high-income, upper middle-income and lower middle-income householders (at the standard 95 percent level of significance).

- *Age*: Age is also an important determinant of willingness-to-pay for broadband, with willingness-to-pay decreasing with age. In particular, there is a significant difference between the higher willingness-to-pay of younger (less than 45 years of age) versus older (45 years of age and older) householders. Younger "Generation Y" householders (where the age of the head of household is between 18-24 years) with average broadband valuation of $31.19 and "Generation X" householders (between ages 25-44) with valuation of $29.80 have a significantly higher willingness-to-pay than boomer and senior householders, but there is no statistically significant difference between GenY and GenX householders, nor between boomers and seniors, again at the 95 percent level of significance.

- *Race/ethnicity*: Race/ethnicity is not a significant determinant of willingness-to-pay for broadband among existing home broadband adopters. The only statistically significant difference among racial groups is between black/African-American householders, who have the average highest additional willingness-to-pay at $32.10, and Latino/Hispanic householders, who have the lowest willingness-to-pay at $24.64. There is no significant difference in broadband valuation among all other racial groups at standard levels of significance (the 95 percent level).[27]

- *Education*: Education is a significant determinant of willingness-to-pay for broadband, with willingness-to-pay increasing with education level. The willingness-to-pay of individuals with higher levels of education (bachelor's degree or more) of $30.19 is statistically significantly higher than for those with only a high school diploma or less ($25.20).

- *Employment*: Employment status is also a significant determinant of willingness-to-pay. The willingness-to-pay of the employed, at $29.56, is significantly higher than that of retired individuals ($26.44), and of the unemployed ($26.69). Differences between students and other groups, and between retired individuals and the unemployed, are not statistically significant.

- *Location*: Urban-rural location of households (based on population density by zip codes) is not a significant determinant of willingness-to-pay for broadband, with urban and rural households valuing broadband equally (with an additional willingness-to-pay of roughly $28.50).

[27] Apart from whites/Caucasians who make up 88 percent of the overall sample before applying representative population weights, the averages here are based on relatively dispersed individual figures and relatively small subgroup sizes, and therefore most differences are not statistically significant: African Americans make up 5 percent of the sample of 3,909 home broadband users, while Hispanics make up 4 percent and Asians (South and Southeast Asian) make up 3 percent.

VI. BROADER SOCIAL BENEFITS FROM PROVISION OF BROADBAND TO HOUSEHOLDS

The primary estimates of the economic benefits of broadband in this paper are based on the benefits to households, as calculated through the consumer surplus those households receive from their purchases of fixed-line broadband services. Focusing on households and their consumer surplus is the appropriate starting point for looking at the economic benefits of broadband, given that (as documented earlier) most of the broadband lines and most of the revenue from broadband are due to household use. However, there are significant kinds of economic benefits from broadband other than household consumer surplus, and thus our estimates should be understood to address only a portion of the overall economic benefits of broadband to the economy as a whole.

For example, consider two types of economic benefits to households from broadband that are not covered by our consumer surplus calculation. First, a household broadband connection can be combined with complementary mobile wireless broadband services to cell phones and other handheld wireless devices. Given current usage patterns, a connection to wireless broadband is still best thought of as a complement to home-based broadband rather than a substitute, and therefore some proportion of the benefits of these broadband yielding wireless devices could be attributed to household broadband service.[28]

Second, many business users of both fixed and wireless broadband services generate significant increases in productivity in their firms from the use of broadband. Indeed, the U.S. comes out on top in the 2009 "Connectivity Scorecard" global rankings (Waverman and Dasgupta, 2009) mainly because U.S. businesses have been making extensive use of computers and broadband, combined with the significant increases in productivity brought about by such use. As business users compete against each other, with all firms making use of broadband in this way, the force of competition means that a significant portion of these productivity gains—which may take the form of innovative new products or lower prices for existing products—will be passed along to households. Unfortunately, lack of data to make such calculations prevents this additional category of benefits from being included in this study.

In addition, the overall social benefits of broadband to the economy include not only economy-wide consumer surplus generated by household users, but also the economic profits and producer surplus earned by broadband-related firms--both providers of the broadband services themselves and providers of value-added services via broadband to households and firms. When producers earn economic profits above and beyond the total costs and expenses required to generate the services provided, these profits are called "producer surplus." Just as consumer surplus arises when consumers would be willing to pay more for a product, but can buy it for less, producer surplus is generated whenever producers are able to sell units of broadband-related services to

[28] Pearce and Pagano (2009) calculate that $17.4 billion additional capital expenditures in new wireless broadband networks will increase GDP by $126 to $184 billion within 2 years, and result in an increase of between 4.5 and 6.3 million jobs.

households at a price that is higher than the minimum price at which they would have been willing to sell. The gains from producer surplus do not accrue to households, but rather to stakeholders of the firms providing the broadband-related services.

There are two main sources of producer surplus and profits from the provision of broadband services to households: from firms that provide the broadband services themselves, and from firms that provide value-added services via broadband to households (such as Google, eBay and Amazon). An accurate estimate of producer surplus and profits at each point in time would require considerable information. For example, it would be necessary to determine the costs of providing a unit of these services, including R&D expenses, disaggregated by the residential household broadband (non dial-up) market segment. Moreover, an overall estimate of producer surplus would need to weigh how some firms will lose profits as a result of the deployment of broadband by other competing firms. As a concrete illustration, any producer surplus accrued by telephone company providers of broadband fiber and DSL services should be offset by measures of their loss of profits caused by free broadband-enabled video and voice calls—for example, facilitated by software such as Skype—though in this case, from the economy-wide perspective, the loss is somewhat counterbalanced by gains in consumer surplus from users of Skype. As another example, the profit gains earned by Google from dealing with households via broadband, particularly through those services that are only attractive enough to use with broadband, should be offset to some extent in an overall producer surplus calculation by the profit losses to newspapers and other displaced print-media providers from reduced classified advertisement revenues. The overall point here is that measuring producer surplus for an individual firm is very difficult, and measuring producer surplus and profits for the economy as a whole, given offsetting effects across firms, is even more difficult.

Here, we offer a rough approximation of one part of producer surplus, using accounting profits as a proxy that is intended only to illustrate the likely order of magnitude of the underlying producer surplus. Based on the percentage of accounting profits generated in the U.S. from broadband-related operations for three of the top Internet service providers and five of the top providers of value-added services via broadband, an estimated proxy of producer surplus increases from $5.8 billion in 2005 to $10.6 billion in 2008.[29] The estimated household consumer surplus benefits of roughly $32 billion in 2008 are still large relative to these figures. However, this rough "order of magnitude" approximation of producer surplus again highlights that the overall benefits to the economy from broadband are significantly greater than $32 billion per year.

[29] Three of the top five Internet service providers were selected from the ranking at www.isp-planet.com/research/rankings/usa.html (December 2008). The estimates are based on assumptions regarding the extent of operating income arising from US household broadband-related operations. Income from operations in 10-K filings with the SEC was used as a proxy for economic profit. Wherever relevant and available, the percentage of consolidated revenues generated in the US was used as a proxy for the percentage of income from operations generated in the US. A measure of household broadband segment operating revenues as a percent of total operating revenues was calculated as a proxy for the percentage of income from operations generated from broadband households. Wherever not available, a ratio of 72.5 percent was used, based on mid-point of 70 to 75 percent of broadband revenues from households calculated by Greenstein and McDevitt (2009).

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TECHNICAL APPENDIX

This appendix provides details on the methodologies used for calculations mentioned in this study and additional supporting results: 1) Calculating consumer surplus based on price and quantity data from roughly 30,000 households per year for 100 Metropolitan Statistical Areas, in section III.2; 2) Calculating odds ratios for home broadband adoption for key demographic characteristics, in section V.1; 3) Calculating willingness-to-pay for home broadband by demographic characteristics, in section V.2.

(1) Calculating Consumer Surplus Based on Price and Quantity Data

We estimate Internet demand and willingness-to-pay econometrically with a specification derived from the nested logit model, which is a relatively flexible rigorous theoretical model of consumer demand. For this reason, the nested logit model is frequently utilized in recent empirical studies of consumer demand and consumer welfare, especially where it is important to allocate products into groups with different degrees of substitution due to differences in their characteristics.

In our model, each household is assumed to select a single Internet service from several options. Products within the same group (or "nest") are closer substitutes than products from other groups. We consider two main groups, broadband (which contains cable modem, DSL, satellite and fiber as substitutes within the same nest) and dial-up, with one additional group for the "outside good," namely no Internet, as households may decide not to purchase any of the inside options.

Following the literature on discrete choice demand modeling (for example, Berry, 1994), we assume that the utility of representative household *i* from consuming product *j* is given by (for convenience we suppress the subscripts for a given market, namely a specific geographical area and time period):

$$u_{ij} = \delta_j + \zeta_{ig} + (1 - \sigma)\,\varepsilon_{ij} \qquad (1)$$

Each household *i* chooses the product *j* that maximizes its utility. Here the first term, δ_j, is the average utility or valuation of product *j*, assumed common to all consumers in a given market. It depends on x_j, one or more non-price observed characteristics of product *j* for which we have data (in our case limited to an Internet connection type dummy as speed is not reported – and has been typically assumed to be poorly reported when available), an additional rural intensity variable r specific to each market and interacted with the product characteristic term (to allow household preferences to vary across markets depending on whether a given market is more or less rural in intensity), the price of product *j*, p_j, and an error term ξ_{ij} (reflecting unobserved characteristics), where α, β_1 and β_2 are parameters to be estimated (α has to be positive to be consistent with utility maximization, so that consumers respond to a price increase by reducing demand):

$$\delta_j = \beta_1\, x_j + \beta_2\,(x_j{*}r) - \alpha\, p_j + \xi_{ij} \qquad (2)$$

The second and third term in (1), ζ_{ig} and ε_{ij}, are random variables that reflect household i's deviation from the mean valuation.[30] In order to compute the probability that a household chooses product j, both ζ_{ig} and $\zeta_{ig} + (1 - \sigma)\,\varepsilon_{ij}$ are assumed to have the Type 1 extreme value distribution; it is this assumption that gives rise to the logit form of demand. The parameter σ has to lie between 0 and 1 to be consistent with utility maximization. It measures the strength of the nest, that is, the correlation of consumers' utility levels across products within the same group. If $\sigma = 1$, there is perfect correlation of preferences within the same group, so that these products are perceived as perfect substitutes. If $\sigma = 0$, there is no correlation of preferences so that consumers are equally likely to switch to products in a different group as to products within the same group in response to a price increase; in this extreme case, the model reduces to a standard flat logit in which products compete symmetrically.

We estimate the following linearized nested logit demand system, which is implied by the utility function described in (1) following the transformation described in Berry (1994):

$$\ln(\text{dial-up share/NoInternet sh}) = \beta_1 D_{du} + \beta_2 (D_{du}{*}r) + \alpha\, p_{du} + \varepsilon \qquad (3)$$
$$\ln(\text{bb type share/NoInter. sh}) = \beta_1 D_{type} + \beta_2 (D_{type}{*}r) + \alpha\, p_{type} + \sigma \ln(\text{type sh/bb sh}) + \varepsilon$$

where β_1, β_2, α and σ are parameters to be estimated, dummies capture the effect of non-price product characteristics, the rural intensity variable r varies by MSA and year, and broadband-type shares and prices are separate average shares and prices by MSA and year for each of cable modem, DSL, satellite and fiber. As there are up to four broadband types, the system of equations consists of a stack of up to five observations for each of the 100 Metropolitan Statistical Areas (MSAs) per year, or a maximum of 20,000 observations. As observations for fiber are only available starting in 2007, the underlying assumption is that each household faced a more restricted choice set in the prior years.

A key advantage of the linearized logit approach is that it allows for estimation by traditional instrumental variables techniques. Consistent econometric estimation of α and σ requires that we estimate these share equations with instruments for prices and within-nest shares, as these terms are endogenously determined. Appropriate instruments need to vary geographically and over time, so that they are correlated with the endogenous explanatory variables, but are uncorrelated with the unobserved demand shock in the given region (the error term in the explanatory equation). Following Hausman (1996), we exploit the cross-section time series structure of the data, using prices from other geographic markets in the same time period as instruments for prices and shares in a given market. Given that there are two endogenous variables, we allow for additional variation in instruments by introducing four regional price instruments (East, North-East, South and West) for each observation. This approach assumes that the prices in each MSA are determined to a significant extent by exogenous variation in the common costs of technology and supply in the national and regional markets, as well as by local demand conditions.

[30] The term ζ_{ig} is consumer i's utility common to all products belonging to group g. The term ε_{ij} is consumer i's utility specific to product j.

A key advantage of this extended nested logit model is that the inclusion of a rural intensity indicator allows household preferences for Internet services to vary depending on the share of rural households present in any given MSA. The rural intensity indicator is created from the zip codes of each household in our sample, based on census data on land area and total population. Rural zip codes are designated as those with a population density of less than 1,000 people per square mile.[31] We then ranked our 100 MSAs according to the share of observations from rural zip codes. Given that the distribution of MSAs according to rural intensity is fairly smooth and continuous, with the most urban MSA in 2008 having 7 percent rural households, the 50th MSA having 44 percent rural households, and the most rural MSA having 87 percent rural households, we concluded that this variable should be used as a continuous variable rather than a discrete (0,1) variable. By interacting this rural indicator with the product dummies, the valuations of the non-price product characteristics are allowed to vary by MSA according to the magnitude of the urban-rural household mix.

The results for the basic nested logit model estimated by both ordinary least squares (OLS) and instrumental variables (IV) are given in Table A1, together with our preferred extended model where the impact of variations in the mix of urban and rural households is explicitly accounted for. The increase in the responsiveness of demand to price (α) in the basic IV regression relative to OLS is consistent with the use of an instrument that removes joint endogeneity of the price variable. In addition to the regional price instruments, which were highly significant in the first stage of the IV regression (not reported), time fixed effects also were included, as they also were highly significant in determining fitted prices and shares. The high positive value of σ in the basic IV regression (0.93) suggests that cable modem, DSL, satellite and fiber are perceived as very strong but less than perfect substitutes, with a significant difference in correlation of preferences among the four within-nest broadband modes versus dial-up. The significant positive coefficients on the broadband modes relative to dial-up, conditional on price, indicate a much higher average willingness-to-pay or marginal utility for broadband modes relative to dial-up in spite of dial-up's lower price.

The final column in Table A1 reports the results from the IV regression with varying urban-rural preferences. The slightly lower but still significant value of σ suggests broadband connection technologies remain much stronger substitutes for each other relative to dial-up, though allowing for variation in household preferences according to population density reduces the strength of the broadband nest somewhat. In particular, the significant positive coefficient on the rural indicator interacted with satellite (and the corresponding insignificant coefficient on the non-interacted satellite dummy which now captures the urban effect) indicates a strong preference for satellite by rural households. Conversely, the significant positive coefficients on the cable modem, DSL and fiber dummies (and the corresponding insignificant/negative coefficients on the rural indicator interacted with cable modem, DSL and fiber) indicate a strong preference

[31] The U.S. Census Bureau's classification of "rural" consists of all territory, population, and housing units located outside of urban areas and urban clusters, which consist of core census blocks or blocks that have a population density of at least 1,000 people per square mile. See www.census.ogv/geo/www/ua/ua_2k.html.

for these connection technologies by urban households. These preferences are no doubt at least in part influenced by differential urban-rural availability of these broadband options. Again, the larger positive coefficients on the cable modem, DSL and fiber connection types relative to dial-up, conditional on price, indicate a higher willingness-to-pay or marginal utility for these broadband modes relative to dial-up in spite of dial-up's lower price.

Table A1: NESTED LOGIT BROADBAND DEMAND ESTIMATES

	Regression Method		
Variable	**Ordinary least squares**	**Instrumental variables**	**Instrumental variables with varying urban-rural preferences**
Price (α)	0.003**	0.058***	0.062***
	(0.001)	(0.009)	(0.009)
Log of inside share (σ)	1.003***	0.929***	0.733**
	(0.026)	(0.295)	(0.298)
Intercept (dial-up)	-0.015	1.023***	1.087***
	(0.036)	(0.172)	(0.198)
Cable modem	0.975***	2.177***	2.298***
	(0.051)	(0.240)	(0.308)
DSL	0.949***	1.683***	1.765***
	(0.047)	(0.252)	(0.259)
Satellite	1.064***	2.405**	1.086
	(0.129)	(1.219)	(1.444)
Fiber	1.357***	2.151**	1.830*
	(0.111)	(1.013)	(0.998)
Cable modem_rural			-0.338
			(0.229)
DSL_rural			-0.408*
			(0.224)
Satellite_rural			1.499**
			(0.619)
Fiber_rural			-0.681*
			(0.395)
Dial-up_rural			0.023
			(0.204)
No. of (unweighted) observations	1,573	1,573	1,573

Source: Forrester data based on households from the top 100 MSAs for each year. Standard errors in parentheses: *** indicates significance at 99% level; ** at 95% level; * at 90% level.

Note: The dependent variable is the logarithm of Internet connection type shares relative to the No Internet share, with a stack of up to 5 Internet connection types (dial-up, cable modem, DSL, satellite and fiber) for each of the 100 MSAs per year.

Table 5 in the main text reports the elasticities of demand and consumer surplus based on our preferred extended nested logit model parameter estimates. The estimates of the parameters α and σ, together with underlying shares, determine the estimated price elasticities of demand and consumer surplus values. Given the logit structure, the own and cross elasticities can be expressed as:

$$\eta_{ii} = - \alpha\, p_i\, [share_i - (1/1\text{-}\sigma) + (\sigma/1\text{-}\sigma)\,(share_i/bb\ share)] \quad (4)$$
$$\eta_{ij} = \alpha\, p_j\, [share_j + (\sigma/1\text{-}\sigma)\,(share_j/bb\ share)]$$

And under the assumption of the nested logit model, the net consumer surplus is given by the expected value of the maximum of utilities:

$$CS = 1/\alpha\ \ln [1 + \exp (\delta_{du}/1\text{-}\sigma)^{1 - \sigma} + \textstyle\sum_i \exp (\delta_i /1\text{-}\sigma)^{1 - \sigma}] \quad (5)$$

Equation (5) is the consumer surplus for a representative household in a specific market, namely an MSA in a given year – where the MSA-specific average household valuations (the δ's) reflect the average price for dial-up and broadband service choices, the estimated non-price product characteristic effects (captured by dummies for each Internet connection type), the variation in these effects according to household preferences in more or less rural markets, and fitted residuals. The valuation of the different Internet connection types are all measured relative to the utility of the "outside good", which is assumed equal to zero in the standard logit model approach.

To extrapolate from our sample of the top 100 MSAs to the U.S. population, we made two adjustments to our consumer surplus estimates in order explicitly to account for the more rural regions of the overall economy. The first adjustment has already been described, namely to include a variable in the estimation of the consumer surplus for each of the 100 MSAs that reflects the rural intensity of each MSA in the sample. A second adjustment is required accurately to reflect the higher average rural intensity of the rest of the country, beyond the sample's 100 MSAs. To accomplish this on the basis of our estimation of the impacts of rural intensity, we adjust the average consumer surplus per household from the econometric estimation of the sample's 10 most rural MSAs (where 70 percent or more of the household observations in each MSA had rural zip codes) by using the actual rural intensity for the remainder of the country based on U.S. Census Bureau data (by calculating a population-weighted average of the rural intensity indicator for all U.S. zip codes outside of our 100 MSAs).[32] We assume that all the households in the country not covered by the sample's 100 MSAs have this estimate as their average consumer surplus. We then scaled up the household-level consumer surplus for each of the 100 MSAs by the number of households in each MSA, and scaled up the consumer surplus for the remainder of the country by the number of households outside the top 100 MSAs. Finally, we multiplied this combined monthly consumer surplus estimate by 12, yielding our reported annual home Internet consumer surplus estimates.

[32] In re-computing the δ's for the consumer surplus calculation, we now use the "remainder of the country" rural intensity value interacted with the product characteristic terms together with our estimated parameters as specified in equation (2). We take the average prices across the 10 most rural MSAs as our best available proxy for prices faced by households in the remainder of the country. We have two available choices for the residual term that reflects unobserved characteristics: either to set residuals equal to zero, or to take the average residuals from the 10 most rural MSAs. We do the calculations separately for both options, and report the more conservative, lower set of consumer surplus estimates based on setting the residuals equal to zero (which appears to us as the best available proxy for out-of-sample residuals). Our headline national consumer surplus estimate of broadband relative to no home Internet for 2008 would be $33.4 billion with the average residuals from the 10 most rural MSAs, versus our reported estimate of $31.9 billion.

The economy-wide consumer surplus estimates for home broadband relative to no Internet were then calculated by using the same estimated preferences for each connection type but now assuming a counterfactual in which broadband is in the choice set but dial-up is not available. This amounts to calculating a variant of equation (5) which includes broadband (the last term summing across the broadband service choices) and the outside good, and then weighting and scaling up these broadband consumer surplus estimates with the same technique. The consumer surplus estimates for broadband relative to dial-up were calculated by taking the difference between equation (5) and a variant of equation (5) without broadband, and then again weighting and scaling up these broadband consumer surplus estimates with the same technique.[33]

(2) Calculating odds ratios of home broadband adoption for key demographic characteristics

Tables A2 and A3 present the odds of home broadband adoption, conditional on connecting to the Internet at home and controlling for household size and broadband price,[34] among all households and among home Internet users, respectively, for specific values of demographic characteristics: 0-1 indicator or dummy variables have been used to capture the presence of the separate categorical effects for income, age, race/ethnicity, education, employment and location (population density). A higher odds ratio means that broadband choice is more likely to have occurred.[35]

The results from year-by-year logit broadband choice regressions with maximum likelihood estimation point to a number of important patterns that complement and strengthen the findings reported in section V.1:

- *Household income:* The odds of adopting home broadband increase with income. Among all households (Table A2), a high-income household (with annual household income exceeding \$100,000) was 4.7 times more likely to adopt broadband than a low-income household (with annual income less than \$25,000) in 2005, and this ratio rose to 7.25 times by 2008. Among Internet households, this same ratio was 2.4 in 2005, increasing to 3.7 in 2008. The differences in odds ratios among lower middle-income, upper middle-income, and high-income households also are statistically significant.

[33] In both of these calculations, we are essentially allowing households to re-choose from a modified choice set but based on the estimated household preferences, which explains why it is appropriate to scale up based on the entire national household population.

[34] We include MSA fixed effects in the logit regressions to control for broadband price and other unobserved variation across MSAs.

[35] The odds ratio is calculated as the exponential function of the logit regression coefficient. Odds ratios capture the likelihood that an event (represented by the dependent variable, in this case broadband adoption) will occur given the value of a right-hand side variable, and thereby allow the impact of other demographic variables to be controlled for. We present two tables here to parallel the two reported broadband adoption rates in section V.1. An odds ratio of one means that the probability of an event occurring is 50 percent. For example, in Table A2, the odds of a boomer head of household in 2008 adopting home broadband, holding all else fixed, is 0.22 to one, or substantially less likely than 50 percent. This can be converted into a probability: 0.22/(1+0.22) = 0.18.

- *Age:* The odds of adopting home broadband decrease with age. A GenX household (where the age of the head of household is between 25 and 44 years) is about half as likely to adopt broadband as a GenY household (ages between 18-24), with odds ratios between 0.44 and 0.59 among all households (Table A2), and between 0.39 and 0.67 among Internet users (Table A3). A senior household (ages 65+) is about a sixth as likely among all households with odds ratios between 0.11 and 0.17 (Table A2), and among Internet households with odds ratios between 0.14 and 0.31 (Table A3). The differences in odds ratios between GenX, Boomer and Senior households also are statistically significant.

- *Race/ethnicity:* Race/ethnicity matters less over time in the choice of broadband: among all households, the odds of selecting broadband relative to white/Caucasian households were not statistically significantly different for Asian and Latino/Hispanic households by 2008, though they were lower for black/African-American households (Table A2).

- *Education:* The odds of selecting broadband are significantly higher for households with a college degree or more. These more educated households are between 2.1 and 2.8 times more likely to select broadband relative to households with less than high school diplomas (among all households, Table A2), and between 1.2 and 1.6 times more likely to select broadband relative to households with less than high school diplomas (among Internet users, Table A3).

- *Employment:* In 2008, relative to households where the head of household is employed or part-time employed, the odds of selecting broadband were statistically significantly lower (at the 95 percent level) where the head of household was unemployed (in both Tables A2 and A3).

- *Location (based on population density):* Relative to urban households, the odds of selecting broadband were statistically significantly lower where the head of household was rural (in both Tables A2 and A3).

Table A2: ODDS RATIOS OF BROADBAND ADOPTION BY DEMOGRAPHIC CHARACTERISTICS

Variable	2005	2006	2007	2008
HOUSEHOLD INCOME (relative to: low income, less than $25K)				
lower middle income ($25-50K)	1.70***	1.90***	2.05***	1.80***
upper middle income ($50-100K)	2.99***	3.15***	4.03***	3.69***
high income (+$100K)	4.69***	5.88***	7.01***	7.25***
AGE OF HOUSEHOLDER (relative to: GenY, 18-24 years old)				
GenX (25-44)	0.48***	0.52***	0.59***	0.44***
Boomer (45-64)	0.34***	0.29***	0.33***	0.22***
Senior (65+)	0.17***	0.16***	0.17***	0.11***
RACE/ETHNICITY (relative to: white/Caucasian)				
Black/African American	0.67***	0.59***	0.66***	0.71***
Asian	1.23***	1.34***	1.00	1.00
Latino/Hispanic	0.87***	0.95	0.88*	1.05
EDUCATION (relative to: less than High school diploma)				
High school diploma	1.22***	1.32***	1.56***	1.51***
Some college	1.82***	1.90***	2.27***	2.23***
Bachelors degree or more	2.13***	2.24***	2.56***	2.78***
EMPLOYMENT (relative to: employed)				
Part-time employed	1.06	1.08*	1.08	1.02
Retired	0.80***	0.88***	1.00	0.87***
Unemployed	1.00	1.00	0.97	0.86***
POPULATION DENSITY (relative to: urban)				
Rural	0.77***	0.78***	0.76***	0.85***
No. of (unweighted) observations	32,569	30,495	22,388	23,814

Source: Forrester data. *** indicates significance at 99% level; ** at 95% level; * at 90% level.

Note: The dependent variable is a discrete (0,1) variable where 1=broadband and 0=dial-up or no home Internet. Odds ratios are derived from the maximum likelihood estimates.

Table A3: ODDS RATIOS OF BROADBAND ADOPTION AMONG INTERNET USERS, BY DEMOGRAPHIC CHARACTERISTICS

Variable	2005	2006	2007	2008
HOUSEHOLD INCOME (relative to: low income, less than $25K)				
lower middle income ($25-50K)	1.09*	1.30***	1.30***	1.19***
upper middle income ($50-100K)	1.57***	1.79***	2.12***	1.95***
high income (+$100K)	2.38***	3.28***	3.34***	3.73***
AGE OF HOUSEHOLDER (relative to: GenY, 18-24 years old)				
GenX (25-44)	0.52***	0.52***	0.67***	0.39***
Boomer (45-64)	0.43***	0.33***	0.40***	0.20***
Senior (65+)	0.31***	0.25***	0.26***	0.14***
RACE/ETHNICITY (relative to: white/Caucasian)				
Black/African American	0.77***	0.74***	0.79***	0.92
Asian	1.22**	1.35***	1.00	1.02
Latino/Hispanic	0.94	1.06	0.94	0.92
EDUCATION (relative to: less than High school diploma)				
High school diploma	0.93	0.97	1.31***	1.09
Some college	1.13*	1.18**	1.54***	1.22**
Bachelors degree or more	1.22***	1.23***	1.61***	1.47***
EMPLOYMENT (relative to: employed)				
Part-time employed	1.00	1.00	1.02	0.96
Retired	0.90*	0.90*	1.15**	1.00
Unemployed	1.07	1.04	1.04	0.85**
POPULATION DENSITY (relative to: urban)				
Rural	0.71***	0.74***	0.62***	0.65***
No. of (unweighted) observations	23,735	24,361	17,952	19,785

Source: Forrester data. *** indicates significance at 99% level; ** at 95% level; * at 90% level.

Note: The dependent variable is a discrete (0,1) variable where 1=broadband and 0=dial-up. Odds ratios are derived from the maximum likelihood estimates.

(3) Calculating willingness-to-pay for home broadband by demographic characteristics

Figure A1 presents a graphical representation, and Table A4 presents the estimates of a linear regression with willingness-to-pay for home broadband as the dependent variable and demographic characteristics as the explanatory variables, based on the willingness-to-pay responses from the March 2009 survey. The table presents willingness-to-pay by demographic characteristics (with 0-1 indicator or dummy variables having been used to capture the presence of the separate categorical effects for income, age, race/ethnicity, education and employment groups) relative to a base demographic group, which could be termed as the "emerging Joe-Six-Pack" group: low income (annual household income of less than \$25,000), young "generation Y" householders (18-24 years old), white/Caucasian, high school diploma or less, and employed. The base group's willingness-to-pay for broadband is \$27.67 per month (given by the intercept term in the regression). The key patterns that complement and strengthen the findings for broadband use reported in section V.2 are:

- *Household income*: Relative to the willingness-to-pay of households with low income and the other characteristics of the base demographic group, the willingness-to-pay of all higher-income households is significantly higher.

- *Age*: Relative to the willingness-to-pay of GenY householders (where the age of the head of household is between 18-24 years) and the other characteristics of the base demographic group, the average willingness-to-pay of all older household groups is significantly lower.

- *Race/ethnicity*: There is no statistically significant difference in willingness-to-pay between white/Caucasian, black/African-American, and Asian households at the 95 percent level of significance. Latinos/Hispanics have on average a significantly lower willingness-to-pay, relative to the base demographic group.

- *Education*: Relative to the willingness-to-pay of householders with high school diploma or less and the other characteristics of the base demographic group, the average willingness-to-pay of householders with a bachelor's degree or more is significantly higher.

- *Employment*: Relative to the willingness-to-pay of employed householders and the other characteristics of the base demographic group, there is no statistically significant difference in willingness-to-pay of the other employment groups at standard levels of significance (the 95 percent level).

Figure A1: WILLINGNESS-TO-PAY BY DEMOGRAPHICS
(point estimates and 95% confidence intervals)

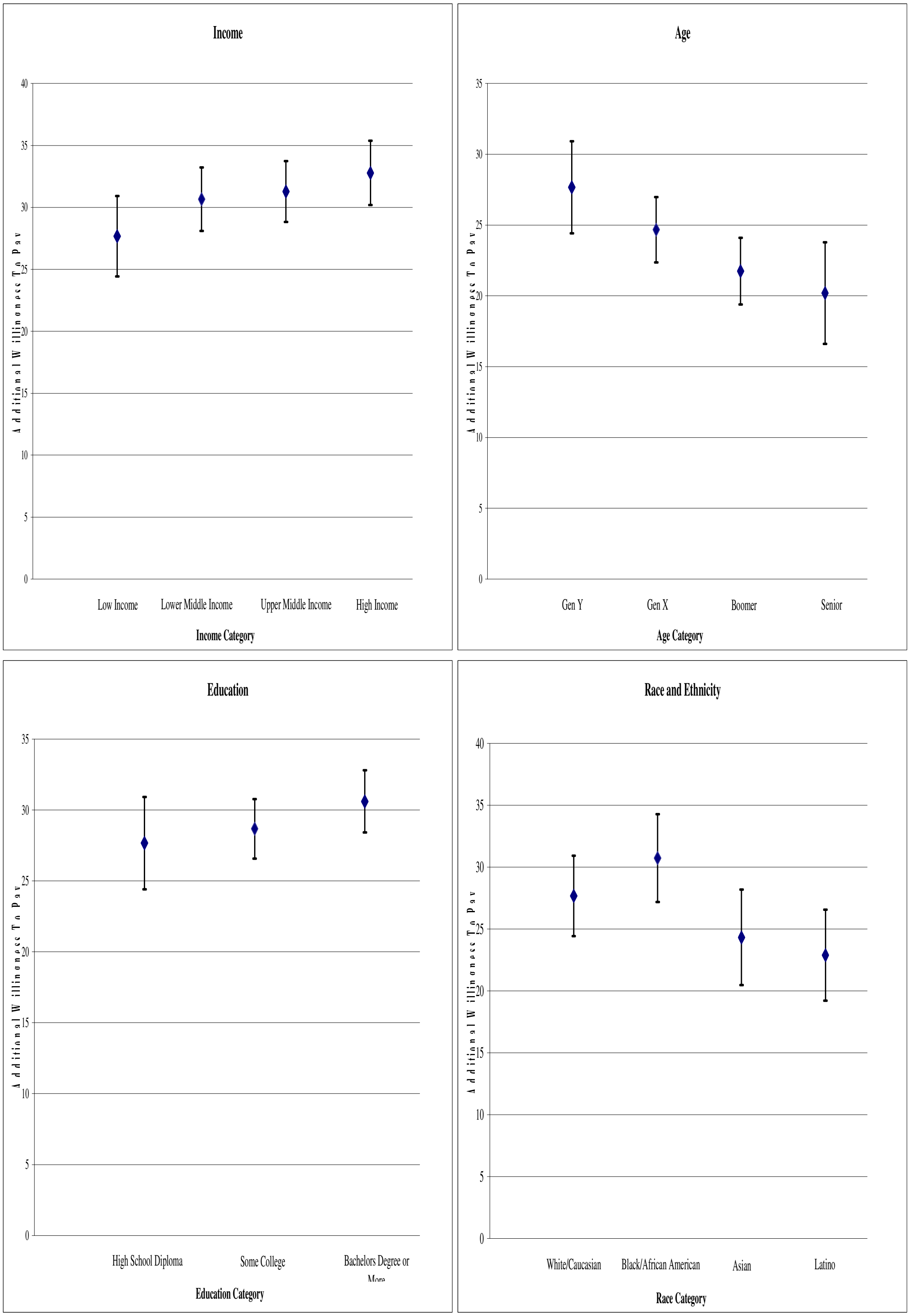

Table A4: WILLINGNESS-TO-PAY REGRESSION BY DEMOGRAPHIC CHARACTERISTICS

Control group WTP: low income, GenY, white, employed, high school diploma or less, urban

Variable	Parameter Estimate	WTP Estimate
Constant (Control group WTP)	27.67***	$27.67
HOUSEHOLD INCOME (relative to: low income, less than $25K)		
lower middle income ($25-50K)	2.99**	$30.66
upper middle income ($50-100K)	3.62***	$31.29
high income (+$100K)	5.11***	$32.78
AGE OF HOUSEHOLDER (relative to: GenY, 18-24 years old)		
GenX (25-44)	-3.00**	$24.67
Boomer (45-64)	-5.91***	$21.76
Senior (65+)	-7.48***	$20.19
RACE/ETHNICITY (relative to: white/Caucasian)		
Black/African American	3.06*	$30.73
Asian	-3.35*	$24.32
Latino/Hispanic	-4.78**	$22.89
EDUCATION (relative to: high school diploma or less)		
Some college	1.01	$28.68
Bachelors degree or more	2.93***	$30.60
EMPLOYMENT (relative to: employed)		
Student	-1.34	$26.33
Retired	0.09	$27.76
Unemployed	-1.73*	$25.94
POPULATION DENSITY (relative to: urban)		
Rural	0.92	$28.59
No. of (unweighted) observations	4,201	

Source: Forrester March 2009 data. *** indicates significance at 99% level; ** at 95% level; * at 90% level.

Note: The dependent variable is willingness-to-pay (WTP). The "parameter estimates" represent willingness-to-pay relative to the constant (control group). The "WTP estimates" are the parameter estimates added on to the constant, and therefore represent willingness-to-pay of the control group allowing one specific demographic characteristic to vary (e.g. the reported willingness-to-pay of $30.73 is for an African American household part of the low income, GenY, employed, high school diploma or less, and urban control group, versus the reported willingness-to-pay of $32.10 in Table 7 of the main text, which refers to the "average" African American in the sample, meaning without controling for any demographic characteristics).